SIGA

Integrated System for Municipal Environmental Management

Methodological guide for the construction of SIGA

Planning for prevention of environmental and natural disasters

IDRC CRDI

Canada

Index

Edition: Gastón Bouchard, Alicia Iglesias (IDRC)
Design: Diseño Básico
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PREFACE

Over the years, the International Development Research Centre (IDRC) of Canada has been supporting the incorporation of information systems for urban environmental decision-making in municipalities throughout Latin America and the Caribbean. This research conducted by the Faculty of Science of the University of the Republic of Uruguay, was initially conceived for the purpose of managing new events posing urban environmental risks. Within this context, the research outcomes were enhanced with the production of a tool to support integrated risk and urban vulnerability management in case of natural disasters, the so-called Integrated Municipal Environmental Management System (Sistema Integrado para la Gestión Ambiental Municipal - SIGA, in Spanish).

SIGA was intended for local use and is geared to facilitate the advisory task of municipal technical experts, decision makers, members of civil society and land use planners. This tool is based on a methodological integrated management approach that incorporates social and environmental factors to the basic physical variables that describe the territory under study.

In this manual, the authors of the tool have synthesized the learning provided by SIGA users themselves, as well as the results of the knowledge exchanged during different face-to-face and distance training courses carried out for municipal experts in the different sub-regions of Latin America and the Caribbean, within the framework of the former Environmental Management Secretariat (EMS) of IDRC.

Based on the application of geographic information systems (GIS) fundamentals, this manual describes the steps to be taken and the materials to be used to set up an information system that allows municipal technical experts and decision makers to identify, diagnose and map vulnerability and risk areas in a given municipal territory, by building simple indicators that help monitor the evolution of these events.

This version of the SIGA manual incorporates the economic factor into local risk management planning, which allows decision makers to define municipal priorities and availability of resources and thus enhance planning processes relative to Investment in Prevention and Mitigation at the Municipal level (IPMM in Spanish). It also makes it possible to identify opportunities to complement strategies relative to social investment, vulnerability and risk reduction and, finally, also enhance participatory processes relative to education and dissemination. Accordingly, SIGA represents a pre-investment endeavour in terms of municipal prevention and mitigation.

As part of the core activities of the Urban Poverty and Environment Programme (UPE) of IDRC, this manual is a contribution to advancing the process for the reduction of factors that exacerbate the poverty-disaster-environmental degradation relation, by strengthening local management capacities in order to increase local resilience to natural disasters.

With this publication, IDRC contributes to the implementation of the tenets and goals set forth in the Kobe World Conference on Disaster Reduction (WCDR), Japan, 2005, aimed at providing communities with greater resilience to face natural disasters.

International Development Research Centre - Canada.
Walter Ubal Giordano, Senior Programme Specialist.
May 2008


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1. SOCIAL AND ECONOMIC IMPACT OF DISASTERS

Disasters affect over 200 million people a year. The economic losses they generate not only delay the development process, but also use up limited resources which could otherwise be used for social priorities such as the relief of poverty and the improvement of the health conditions and education of the populations concerned.

For example, it was found that the population affected in 28 countries of the Latin America and the Caribbean region (LAC) (1972-99) was over 150 million people; with over 100 thousand dead and over 12 million victims (M. Adamson, 2003). Chart 1 shows the upward trend in the number of disasters per year which have affected the region every year. If this increase of 4% per year is maintained, in only fifteen years the area will undergo the same number of disasters which affected it over a thirty-year period.

Hydrometeorological disasters (Graph 1) are the most frequent type of disasters in LAC: in first place, floods (38%), followed by hurricanes and storms (31%); and in third place, earthquakes and tremors (11%).

Chart 1. Number of disasters/year in LAC (1970-2002)

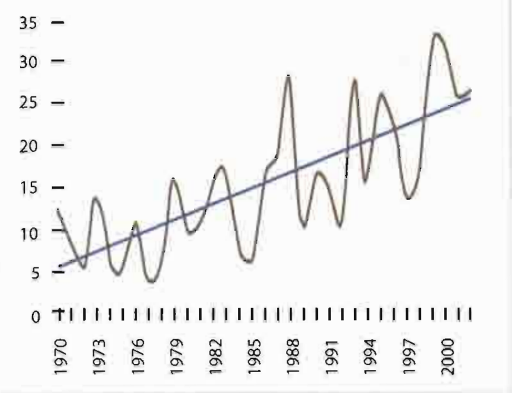
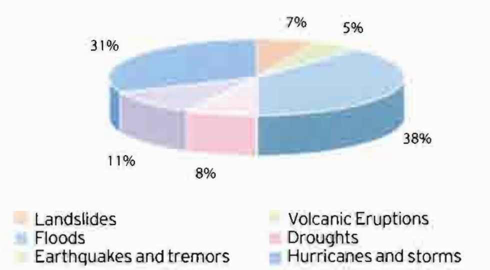


Table 1. Losses (thousands of US$ 1998), number of people affected and deaths by type of disaster, LAC countries (1970 - 2002)

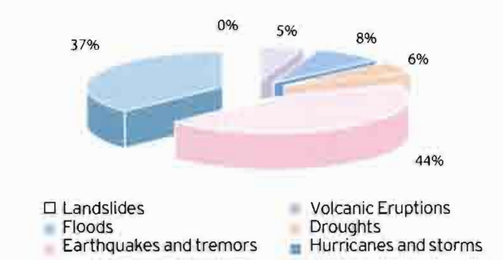
Cause	Consequences		
	Losses $	Number of Persons Affected	Deaths
Landslides	7.011	25.608	4.640
Volcanic Eruptions	1.599.975	677.096	22.836
Floods	2.551.821	15.322.202	37.254
Droughts	1.693.627	5.290.527	41
Earthquakes and tremors	13.340.558	7.446.000	47.357
Hurricanes and storms	11.398.848	21.534.796	33.568
TOTAL	30.591.839	50.296.229	145.696

Graph 1. Break-down of disasters in LAC 1970-2002



Source: M. Adamson, CIESA for ACS (2003).

Graph 2. Losses according to type of disaster, LAC: 1970-2002



Source: Produced by M. Adamson, CIESA 2003 from CRED (2003).

Disasters represent an external blow to the economy, depreciating infrastructure, leading to losses in the production of goods and services, altering relative prices within the economy and the expectations of investors, and affecting the markets in areas such as real estate, tourism and transport, all of which results in a **heavy burden** for sustainable human development.

The effect of the disasters will vary according to type (earthquake, landslide, flood, hurricane, etc.)[1], physical, economic and social conditions (for example, the pattern for use of natural resources, distribution of income and poverty, investment in prevention and mitigation in the area) and, in general, the vulnerability of society in the face of such events.

The dimensions of yearly worldwide socio-economic losses due to disasters are huge. By the year 2000, major disasters exceeded 80 thousand trillion dollars and it is estimated that if the present trend continues, by 2050 they will represent over 100 thousand lives lost per year (Munich Ree, 2000).

For example, during the last three decades, 28 countries in LAC (Table 1) lost over 30.5 billion dollars (1998 constants). Just over 43% (Graph 2) of these losses were caused by earthquakes; 37% by hurricanes and storms, and 8.5% by floods.

[1] In economic terms, an external impact refers to the presence of an event, of a geo-physical type, for example, which is exogenous to the system, and which will impact on the system depending on its structure.

The Cycle: disasters-poverty and environmental degradation

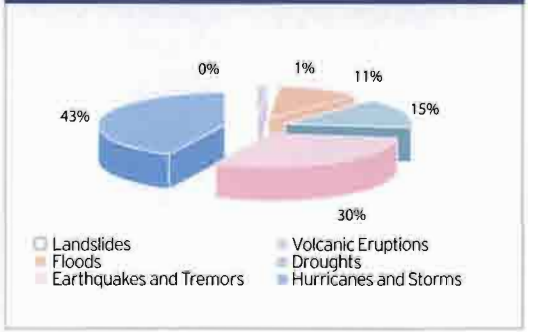
Revealingly for LAC, it has been found that, regarding the effect of disasters on people, hurricanes and storms are responsible for 40% of the people affected (Graph 3), followed by floods (30%), and droughts, which are responsible for 10% of the affected people. Earthquakes only account for 14% of the effects.

Overall, hydrometeorological events cause close to 86% of the social impact of disasters, **which is very serious, since a large proportion of the population affected is poor or very poor.** It is a well-known fact that the poorer settlements and villages of municipalities are located on river banks and on midwatercourses; generally in degraded river basins, as well as in coastal areas where natural barriers (mangrove swamps, wetlands, etc.) have been overexploited, and in urban areas with little rain collection and sanitary infrastructure. This is due to the fact that these lands are less expensive. Thus, a **disaster-poverty-deterioration of natural resources cycle** is established, which feeds itself and **increases the vulnerability** of these municipalities.

If the evolution of economic losses in the region is analyzed over time, it is found that these losses are cyclical (op.cit.). This may reflect periods of greater intensity and dynamism. Therefore, scientific and technological research of the threats (causes, characteristics, frequency, intensity, periodicity and probability or risk of occurrence) is very important for the progress of prevention and mitigation of disaster impact.

All in all, in economic terms, disasters generate an important **depreciation** of physical capital (cumulative processes of investment efforts, for example, in infrastructure); of human capital (cumulative processes of investment in health, education and opportunities for human development which are degraded through loss of life and impact on people) and a depreciation of natural capital (environmental quality and natural resources accumulation).

Graph 3. Break-down of total number of people affected by type of disaster: 1970-2002



Source: Elaborated by M. Adamson de CIESA, for AEC, 2003 using CRED (2003).

The impact of disasters, measured in total losses, offers an indicator of the absolute size of the damage. However, this information says little about the relative importance of the disaster and of the economic system's capacity to respond to this impact.

Table 2 shows the accumulated absolute value of the losses from disasters in Central America, and its relationship to some economic variables. For example, these losses account for close to half of the foreign debt in Central America. Thus, it has been argued (M. Adamson, 2003) that disasters limit or held back the development possibilities of the region. In this area, disasters account for over 80% of exporting capacity. These indicators reflect the relative size of disasters with respect to the economic system.

Table 2. Disasters and economic impact indicators

Category		% of losses per disaster
Disasters*	9.794	100%
External Dept	20.087	49%
Internal Dept	11.892	82%
Exports	11.716	84%
*/ Constant 1998 dollars, so relationships are higher.		

Source: M. Adamson, CIESA, 2003, using data from CMCA.
Constant 1998 US dollars
Source: M. Adamson. CIESA. 2003, with data from CM CA.

Analogously, at the municipal level, indicators may be designed to show the absolute and relative size of the economic impact of disasters, such as total losses in the municipality, losses by sector as a percentage of the sectorial production in the municipality, etc.

The availability of municipal social condition indicators (absolute and relative) is also important. These indicators (of social and economic impact) and their integration with threat and risk indicators offer an overview of the municipality's vulnerability in the face of disasters. If indicators of the economic profitability of investment in prevention and mitigation are added, the capacity (resilience) or degree of adaptability of the municipality may be evaluated.

A. Evolution of the Conceptual Framework Regarding Disasters

Due to the profound social and economic impact of disasters, the international community has made increasing efforts to search for analysis outlines and answers in order to minimize these impacts and to promote societies with ever-increasing capacity to adapt in their response to disasters.

This UPE-IDRC initiative is in accordance with progress made within the conceptual framework of risk management and vulnerability reduction, resulting from summit meetings, which have stimulated the evolution, systematization and integration of knowledge, sound practices and the development of methodologies in this field. Within this conceptual development, two periods stand out: before and after the World Conference at Yokohama and the major challenges faced after Kobe.

World Conference on Disaster Reduction: "A Safer World in the 21st Century"

Held in Yokohama (Japan) in 1994. One of its aims was to carry out a revision of progress achieved in the first half of what is known as the "International Decade for Natural Disaster Reduction" (IDNDR). The Conference congregated over 2000 participants, close to 150 Member States from the United Nations System and partners of IDNDR and its International Framework of Action.

The debate and the Plan of Action were based on ten principles, which may be summarized as follows:

1. Risk identification and assessment.
2. Disaster prevention and disaster preparedness.
3. It is acknowledged that policies and their planning include, as an integral element, prevention of disasters and preparedness (on a national, regional and local scale, and among countries).
4. Fostering the capacity to prevent, reduce and mitigate disasters.
5. The role of early warning, timely dissemination of information and means of communication.
6. Prevention is more effective if it is participatory.
7. Educating beneficiaries on vulnerability reduction.
8. International technological cooperation.
9. Virtuous circles: environmental protection and sustainable development; poverty alleviation and prevention.
10. It is the States´responsibility to protect their societies from disasters, and Developed Countries (DC) are urged to cooperate with the Less Developed Countries

2 See, for example, United Nations document A/CONF. 206/ L, 2005.

The Conference made substantial contributions within the conceptual framework, as well as recommendations for disaster preparedness, which paved the way in that area for the second half of the nineties and the early years of the new millennium.

As a result of a brief summary of documents[2], and more than a decade after the Conference in Yokohama, we have identified two large groups of results and contributions:

a) The valuable legacy of its structured framework of ideas, and

b) its level of influence on pragmatic issues.

The following box summarizes the main contributions:

Box 1. Substantial Contributions of the Yokohama Conference

• Progress within the framework of ideas, range and complexity of vulnerability reduction of (physical, economic and environmental): a proliferation of common terminology was generated with reference to risk reduction, recognized frameworks and applications, which led to management of disasters from an integral perspective. This produced, in the following decade, a diversification of risk reduction management approaches with a strong integration of social science elements.

• The recognition of the need for public policies and strategies aimed at risk reduction: there was a transition from methods centred on preparedness for emergencies to a growing focus on vulnerability and risk reduction, with a marked evolution towards regional and local approaches, with the emergence of the demand for plural and participatory focuses (ISDR, 2006). This is evident in a large number of countries and is manifested by the reformation of juridical frameworks and the proliferation of national plans centred on prevention and mitigation.

• Scientific and technological progess is an interesting incorporation in the identification of threats and the undestanding of events, as a practical contributing factor for vulnerability reduction.

• In the first half of 2000, an official and public undestanding was declared, which stimulated a growing demand for a significantly stronger commitment to reducing vulnerability.

From Yokohama to Kobe: A Search to Overcome Deficiencies

Significantly, ten years later, the basic principles of Yokohama were acknowledged as being currently valid during the World Conference on Disaster Reduction held in Kobe (prefecture of Hyogo, Japan, January 2005)[3]

The evaluation of the Yokohama results, which was carried out before the Kobe Conference, showed that if the strategies and actions for disaster reduction are not included in national plans, the impact of disasters will continue to limit the socio-economic development of countries. It was pointed out in Yokohama that it was important that these actions for reduction should succeed in improving national capabilities and particular emphasis was laid on the local scale (United Nations. A/CONF. 206/ L, 2005).

B. The Kobe Summit

The deficient areas and main challenges of Yokohama[4] became the main subject and a priority for progress, promoted by the World Conference on Disaster Reduction in Kobe, Japan (2005).

These deficiencies in governance and policies; economic and financial risk, knowledge, scientific and technological management; awareness and risk reduction in investing and the relationship with the environment and natural resources, are the pillars on which the Hyogo Plan of Action is based: To increase the resilience of nations and communities in the face of disasters.[5] Chart 2 summarizes the objectives, the declaration, the priorities and the Plan of Action.

One of Kobe's main objectives was to complete the analysis of the Yokohama Strategy and its Plan of Action, in order to update the framework to guide disaster reduction in the 21st century. The aims also returned to the provision regarding vulnerability reduction and risk evaluation contained in the Plan of Implementation of the Decisions of the World Summit on Sustainable Development, to a greater awareness of the significance of disaster reduction policies[6], and to the availability and quality of appropriate information on disasters.

The Conference established the following action priority for the **next decade**: "the considerable reduction of **loss** caused by disasters, both in human lives and in social, economic and environmental losses in communities and countries".

A significant amount of time was devoted to debates on solutions which would integrate Early Warning Systems (EWS) and **public policies and urban risks** and on the incorporation of new technological solutions for EWS.[7] The monitoring of the aims established in the **Millennium Declaration** (2000) was significant in strengthening activities regarding the **reduction of the economic and social impact caused by disasters** worldwide in this century. The Conference emphasized the relationship which appears as **a link between disasters** and the eradication of poverty challenge. It reaffirmed the results of the Johannesburg Summit, indicating the need for participatory sustainable development plans[8].

[3] Over 300 official members took part (countries and organizations with their delegations); among others, ministers, government officials, Non-Governmental Organizations (NGOs), mayors, representatives from cooperation and financing agencies and from technical and research institutions.

[4] According to the UN agreement regarding the "Examination of the Yokohama Strategy and Plan of Action for a Safer World".

[5] United Nations, (2005). World Conference on Disaster Reduction, Kobe, Hyogo, Japan. Pp 6 - 26 and United Nations General Assembly Resolution 58/214.

[6] In accordance with pertinent provisions of the Plan of Implementation of the Decisions of the World Summit on Sustainable Development, held in Johannesburg (South Africa), from 26 August to 4 September 2002.

[7] Due to the great impact of the tidal wave which occurred in the Indian Ocean on 26 December 2004. Among other things, it highlighted the fact that EWS centred on human beings are tools which aid the achievement of a preventive culture, as well as evaluations regarding risk, education and pro-active approaches, which are integrated, multi-sectoral and forewarning of multiple dangers.

[8] Including national and local governments, financial institutions, regional and international organizations, civil society, NGOs, volunteers, the private sector and the scientific community, among others.

Chart 2. World Conference on Disaster Reduction. Kobe, Hyogo (Japan), 2005

Objectives

- To conclude the analysis of the Yokohama Strategy and its Plan of Action to update the guiding frame for disaster reduction in the 21st century.
- To describe in detail specific activities to ensure completion of the pertinent provision on vulnerability, evaluation of risk and conduct of activities in case of disaster.
- To exchange best practices and experiences to encourage disaster reduction in the search for sustaninable development and determine the deficiencies and problems.
- To raise awareness of the importance of disaster reduction policies, for the purpose of facilitating and promoting their aplication; increasing the availability and reliability of proper information on disasters intended for the public and organization.

Declaration

- Recognizes the disaster-poverty relationship and sustainable development and the importance of sectorial paticipation.
- Calls for sensitization to, recognition of and political support for disaster risk reduction and the mobilization of resources.
- Recognizes the importance of investiment in reducing vulnerability.
- Reiterates the reduction of risk in disasters as a primary objective in national policies.
- Demands the development of measurable indicators to evaluate advances in prevention and EWSs.
- Calls for the use of guidelines and clear priorities in order to take action consistent with the Johannnesburg Plan of Implementation, the Millenium Goals and the Kyogo Plan of Action.

Priorities

- To make sure disaster risk reduction is a national and local priority, with a solid institutional aplication base.
- To identify, evaluate and monitor disaster risks and foster early warning.
- To use knowledge, innovations and education to create a security and resilience culture at every level.
- Reduce the underlying factors of risk.
- Strengthen the preparation for times of disaster in order to ensure a good response on every level.

In order to achieve them one must

Plan of Action

- State promotion of sustainable development and proper measures for disaster reduction.
- Legislative and institutional regulatory frameworks for risk reduction.
- Production of specific and measurable indicators.
- Knowing threats and factors of risk.
- Updating information.
- Creating Early Warning Systems as risk indicators.
- Improving information systems.
- Divulging knowledge of and information on threats and vulnerability factors.
- Strengthening communication networks.
- Incorporation of disaster risk reduction in school syllabi.
- Strengthening tecnical and scientific capacity.
- Developing strategies and programs at the sectorial level.
- Establishing food security as a priority.
- Strengthening the capacities of institutions providing services during emergencies.
- Mechanism for risk reduction insurance and reinsurance.
- Participation of the private sector in prevention activities.
- Willingness of both authorities and communities.
- Strengthening and promoting communication.
- Promotion of an emergency fund, among others.

Source: Produced by M. Adamson using:
- World Conference on Natural Disasters Report, Kobe, Hyogo (Japan), 2005.
- World Conference on Disaster Reduction Declaration, Kobe, Hyogo (Japan), 2005.
- Action Plan for the World Conference on Disaster Reduction, Kobe, Hyogo (Japan), 2005.
- Strategy Test and Yokohama Plan of Action for a sefer world, 2005.

From the public policy point of view of, the Summit highlighted the significant role the State must play in protecting the population and its possessions in the face of danger. It reiterated the Yokohama pronouncement on the importance of promoting a culture of disaster prevention and proposed that preventive strategies must become a **central part of each nation's public policies** regarding **risk reduction.**

The Summit granted a central role to the high potential perceived in the increase of **local adaptability or resilience in the face of disasters**, which was classed as a "**very solid investment**", that is, it is highly profitable in economic terms.

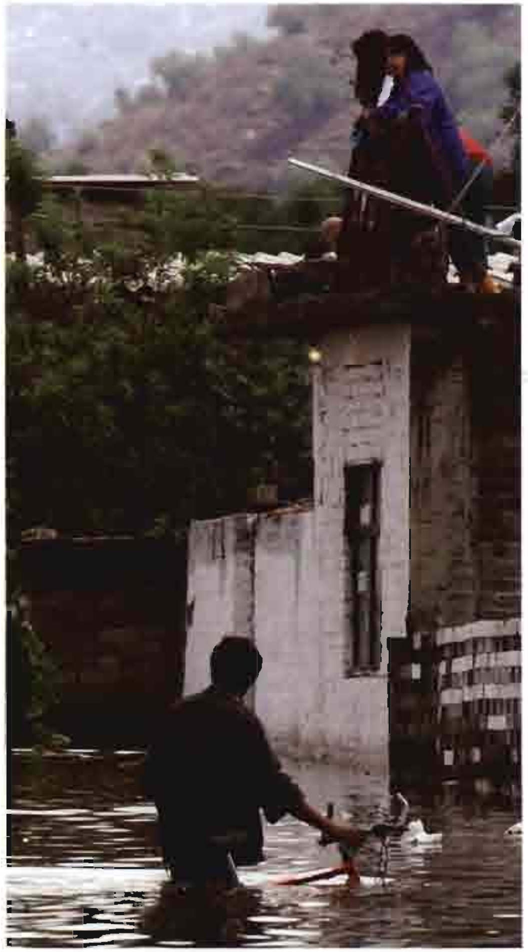
All of the above resulted in a call for the adoption of adequate disaster reduction measures, aiming at an increase in the capabilities of developing countries through technical and financial assistance, due to the fact that these countries are the most vulnerable, via planning and bilateral, regional and international cooperation.

The Hyogo Plan of Action approved for 2005–2015 urges the monitoring of the achievements based on the International Strategy for Disaster Reduction (ISDR), and establishes the need to **create indicators** to monitor the progress of risk reduction activities. Defining the **action priorities** was a valuable contribution, as was also the extensive details of the Plan, which **emphasizes actions at the local level**. The appendix provides a summary of the main items of the Plan of Action.

C. Post-Kobe Challenges

The Summit achieved its purpose of offering a conceptual framework to make progress in disaster reduction in the new century. However, deficient areas persist which represent significant opportunities and complementarities, in which small advances would generate notable benefits in vulnerability reduction, both at the national and local level. Box 2 shows a summary of the main post-Kobe challenges and opportunities.

It is within the framework of this evolution in thought and under the influence of its principles that the **Integrated System for Municipal Environmental Management (SIGA)** emerges as a tool which combines elements for municipal management of vulnerability reduction, through the identification of threats and their risks interacting with the environment, populations and economic activities.



Box 2. Post-Kobe challenges and opportunities

a. To position the vulnerability reduction and resilience objective at the highest level on the agenda and in the priorities of Treasury and Public Finance institutions. It is in the Ministries of Finance that public investment is approved or rejected. Unfortunately, this is a point which has been ignored during the last two decades. It is vital that national investment goals for prevention and mitigation be established, similar to those established for education, health, etc.

b. To achieve economic and financial sustainability. This is a sine qua non for the building of local capacity (local resilience) to develop the significant actions described. For example, National and Municipal Prevention and Mitigation Investment Strategies must be established immediately, with the support of endogenous economic and financial instruments that will allow for one thing, the self-financing of this investment, and for another, a more efficient transfer of risk, both in terms of time and space.

c. Local instruments. At the municipal level in particular, progress mut be made in the development of instruments, methodologies and training processes which will allow the identification of the main threats and risks, and the analysis of decision -making processes regarding investment in vulnerability reduction according to profitability, which will allow the generation of this increase in local resilience.

d. Development of local and municipal incentives, such as tax benefits to reward preventive investment practices in the activities of various sectors in a municipality. These are significant municipal financial actions in generating incentives to strengthen investment in prevention endogenously.

e. Explicit link between social investment programmes and vulnerability reduction. In order to make progress in breaking the poverty -disasters- environmental degradation circle, national social investment programmes (to reduce poverty, provide housing solutions, etc.) need to be connected to measurable objectives and criteria for reducing vulnerability to disasters. At the local and at municipal level in particular this provides a vast area of opportunities that has hardly been explored.

f. Development of goals and quantitative vulnerability reduction indicators as regards the achievements being sought; biannual and five-yearly, at least. Without quantifiable goals that can be monitored, verifying success in meating these major challenges is very difficult and unlikely, and so is the implementation of remedial action for facing them successfully.

Source: M. Adamson, 2007.

D. Economic and financial management for reducing vulnerability at the municipal level

A country's experience in economic and financial management of disasters is a valuable model which must be considered when analyzing the possibilities of prevention management and vulnerability reduction in local governments in general.

Below, a summary is given of the main deficiencies in economic and financial management of disaster reduction found in LAC countries (Adamson, 2003):

Limited quantities. Only half of the countries have a **formal** financial facility or a fund which is structured as such.[9]

Limited Size. Resources in these funds are only sufficient to cover 2% of the economic losses.[10]

Concentration of Funds. The great majority of resources available in those funds are concentrated in very few regions.[11]

Scarce Diversification. The limited financial facilities available, in over 90% of the cases, are restricted to post-disaster funds (dealing with emergencies or mitigation). **Economic and financial instruments for vulnerability reduction are non-existent or very few, such as those designed to promote Investment in Prevention and Mitigation.**

Insufficient financial management of funds and redeployment of resources. Much of these funds is operated in a casual and ad-hoc manner, limited to a simple current account with minimum financial engineering.

Their fragility makes them easy prey. As there is no diversity of economic and financial instruments for the spatial and temporal distribution of risks, when faced with fiscal deficit, those in charge of public funds have chosen to **redeploy accumulated resources**. This is done in order to cover other priorities during disaster-free periods, thus eliminating the principle of temporal distribution of risk which allows for the accumulation of funds through low-risk investments as a way to prepare financially during less intense disaster periods.

Non-existence of indicators for the evaluation of economic and social profitability performance of investments. In general, limited investment in prevention is not the result of prioritization on the basis of economic and social profitability indicators, either ex ante nor ex post.

Scarce integration between risk reduction management and social investment. The greater part of social investment (erroneously called social expenses) is not aligned with the use of these funds and vulnerability reduction priorities. It is usual to find within municipalities, housing programs or school rebuilding projects, etc., located in high-threat areas, even built in the very locations which have previously been flooded.

Erosion, corruption and loss of credibility. The concept of a great "emergency fund" has become worn, due on the one hand to few accountability processes and limited participation of interested sectors; and on the other, to episodes of corruption and fraudulent dealings encouraged by those same factors. These are often facilitated by the discretional and prompt handling which is required for these resources during times of disaster which have been declared national emergencies.

Lastly, limited financial sustainability of funds. Mainly due to the fact that a high proportion (almost 60%) of these funds operates on the basis of resource deviation, or with resources obtained from communities or private sources—therefore, there is no permanent or endogenous funding process. In other words, the flow of resources is not sustainable.

LAC countries are facing the greater part of post-disaster situations (regarding both emergency assistance and the minimal post reconstruction which is carried out) with public resources (including debt),

[9] Adamson. Chap. VII. M. Adamson. CIESA for ACS. Análisis de fondos nacionales en América Latina y el Caribe, en Estudio de Factibilidad Financiero y Económico para un Fondo de Reconstrucción Post-Desastres. 2003. ("Analysis of national funds in Latin America and the Caribbean, in a Financial and Economic Feasibility Study for a Post-Disaster Reconstruction Fund. 2003"). The study used a sample of 17 LAC countries.

[10] When some of the sub-regions are analyzed, as in the case of Central America, existing funds are only sufficient to cover 0.1% of the reported economic losses, that is, they only cover a thousandth part of the damage caused. Even in regions with more attractive funding in financial terms, such as the G-3, reported funds only cover 4% of the economic losses.

[11] The G-3's national funds account for 97% of available funds in that region of LAC.

as well as with local and communal resources. It is evident that international donations and assistance are becoming more and more limited.[12]

Municipal economic and financial management of prevention must incorporate these lessons in order to avoid repeating them on a local scale. It is not the object of this manual to go into these matters in depth, but they do, however, help the SIGA to become an effort which generates activities and results to effectively create greater capacity of adaptation or resilience in the face of disasters in municipalities.

Investment in Municipal Prevention and Mitigation (IMPM) then becomes a significant tool to aid the process of increasing local capacity or resilience, in view of the limited and intermittent resources being used. The potential of IMPM is increased due to the few resources available to minimize post-impact, which do not cover more than 2% of the economic losses.

Thus, if municipalities are not able to develop their own economic management capacity for disasters, based on the use of economic instruments and mechanisms endogenous to their local economic activity, it will be very difficult, if not impossible, for them to reduce their risk and vulnerability levels. This is due to the fact that they will no longer be able to finance investment in a sustained way to achieve greater resilience.

The IMPM has shown to have very high socio-economic profitability, but in spite of this, there is a significant delay in aligning development strategies and public and private IPM, mainly because of the inexistence of profitability evaluation.

Local governments base their financing on tax collection (on properties, for example) and on the collection of duties and rates (commercial, patents, municipal services, etc.).

An efficiently managed IMPM will not only be highly profitable from the point of view of the economic valuation of the benefits generated by the population with relation to their cost, but it will also have a multiplying effect on the value of land and goods in the investment's area of influence. This will in the end result in a better financial balance for the municipality

How can the municipality's threats, vulnerabilities and risks be determined? Where are they located and how are they related to population groups and to productive activities? How can it be determined which areas of the municipality require a greater IMPM? **As will become apparent below, it is precisely the justification and raison d'être of the SIGA to find the answers to these and other questions.**

[12] Countries are mainly financing post-impact by means of their own resources from national funds (25%), in the second place, through redeployment of government funds (20%); local and communal resources (10%) and NGO support (5%), with international cooperation amounting to 16% and finally donations accounting for 13%. External loans barely amount to 7%. (Adamson, M., CIESA, 2003, op cit.).

2. WHAT IS THE SIGA?

From the methodological point of view: it is a tool which uses an integrated approach for the identification and analysis of disaster threats, vulnerabilities and risks, as well as their inter-relationship, on a municipal scale.

The **SIGA** incorporates the main factors which determine the threats to which a municipality is exposed (natural threats and those which result from or are exacerbated by the social and economic system); as well as existing links between the risk of the threat materializing and municipalities' vulnerability. The above is closely related to social and economic factors. Among other possibilities, the SIGA allows the generation of thematic maps and reports which can be prepared from the analysis of SIGA information.

From an economic viewpoint, the SIGA is a pre-investment in municipal prevention and mitigation process, with the ultimate aim of strengthening more sustainable municipal development, with improved knowledge regarding environmental surroundings being gained as the SIGA develops. It is a pre-investment process, since it precedes investment execution processes.

From the point of view of municipal decision makers, once the SIGA has been designed and installed in the municipality, it becomes a value added body of information, which will allow for the evaluation of alternatives, easily complemented by the use of indicators regarding economic, social, and municipal finance profitability (tax collection and other income). The aim of all of the above is to provide technical nourishment for decision-making in IPM processes in strategy planning for risk reduction and vulnerability. This contributes to increasing the levels of resilience or adaptability and to reducing economic and social loss in the municipality when faced with disasters.

From the point of view of a conceptual framework on disasters: the SIGA is an attempt at capturing and systematizing essential aspects of the evolution and development of the conceptual framework achieved throughout several decades and summarized in the Disaster Reduction Conferences (Yokohama and Kobe). It introduces an integral conception which seeks to reduce the impact of disasters and the improvement of capabilities to increase communities´ capacity to adapt (resilience) at the municipal level.

The SIGA introduces a balance between the technocratic aspect of the threat and the social aspect of vulnerability. The former is based on the identification of threats and their measurement, supported by information provided by technology and scientific findings which seek to improve understanding of extreme events. The vulnerability prevention and reduction approach recognizes that the disaster problem is not rooted merely in the presence of natural events, but also in the undesirable impacts which must be minimized. It also depends to a large extent on the location, society and economic systems in which the disaster takes place.

Because of this, the SIGA presents different units of information: depending on the type of threat (hydrometeorological, tectonic, technological); a geophysical information unit, a social and economic information unit, a unit on the use of land and another on the infrastructure of lifelines and services.

These units reflect a broad understanding of terms, in which geophysical events, such as earthquakes, constitute disasters in as much as they affect the economic and social systems located in a given territory. Furthermore, this interpretation includes disasters resulting from the various activities related to the economic system, such as production plans, the use of natural resources and soil; or technological disasters such as leakages of dangerous or contaminating chemicals.

From the monitoring point of view: the SIGA offers a concrete tool in response to the Kobe appeal for the development of measurable and related indicators in terms of threats, risks and vulnerability. It explicitly includes issues of poverty and distribution, presented in the shape of thematic maps, reports and analyses, as well as specific variables of interest.

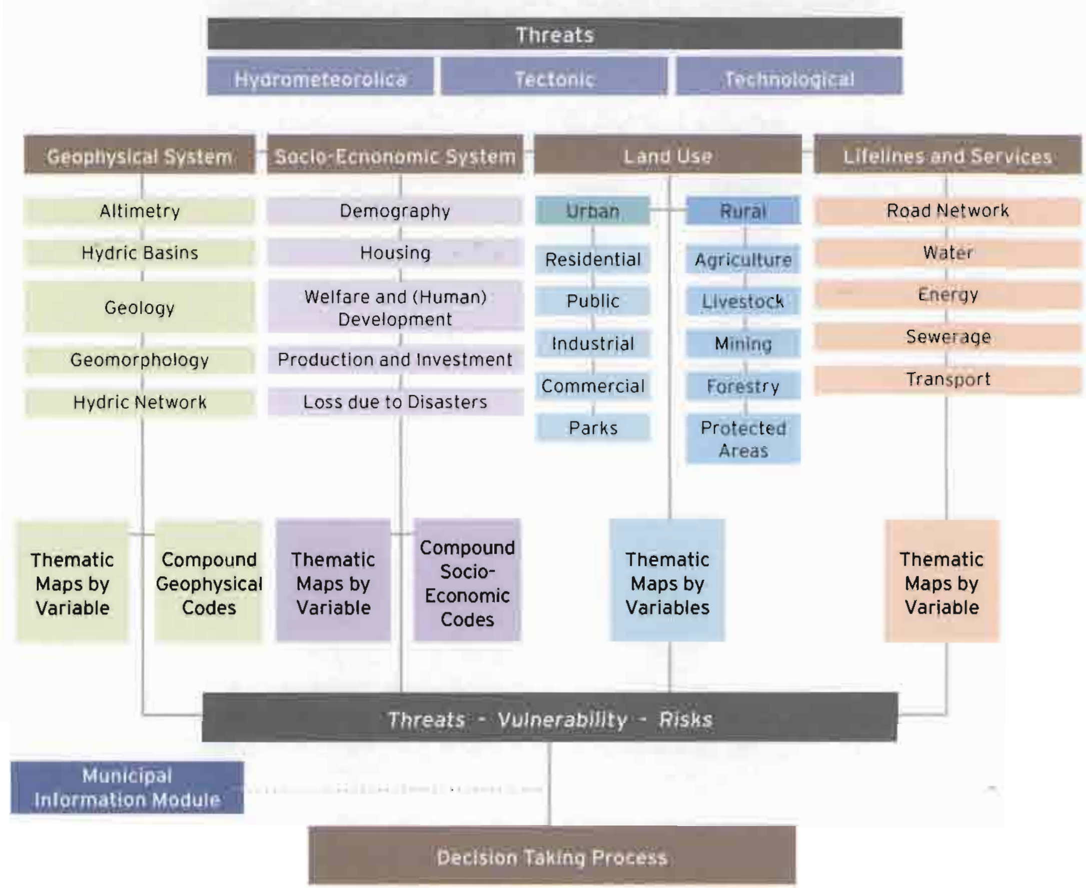
As may be seen in Chart 3, the System does not attempt to offer methodologies for the making of decisions at the municipality level. These will depend on the internal priorities identified by the municipality in relation to the services and projects which it proposes to develop, and on the state of its economic resources (human, infrastructure, processes and financial depending on the municipality's funds). However, the SIGA does have the capacity to show decision makers the overlapping areas in which, for example, actions on education, municipal infrastructure and vulnerability reduction complement and reinforce each other.

A diagram of the basic SIGA principles and foundations for support is shown next. These principles correspond to those which upheld the knowledge framework in Yokohama and Kobe, and seek to make a pragmatic contribution to progress in priority areas and regarding the challenges previously identified.

The SIGA Principles

Planning for sustainability and increased resilience. The SIGA approach establishes general methodological foundations to obtain technical products and input that will nourish in a practical manner the decision-making processes regarding investment planning in prevention and mitigation.

Chart 3. SIGA Schematic Diagram



These inputs contribute to medium and long term territorial management, in order to facilitate risk reduction and vulnerability at the local level (in this case, the municipal level) and thus increase resilience.

Territoriality. Situations involving risk and/or environmental disasters become apparent within a territory. A territory is the physical-temporal space in which inter-connections among diverse social actors, current cultural standards (present-day, ancestral, and acquired) and the physical-natural environment which they inhabit become apparent.

Analytical and systemic vision. The environment is composed of multiple variables and interactions. It is a system and responds in a unique manner to external stimuli. In order to understand the environment's organic workings, analytical knowledge of the variables and their interactions is necessary, so that the central elements required to reduce vulnerability and its associated risks can be determined. The SIGA facilitates the incorporation of advances in knowledge and spatial information (aerial photography, satellite images and information derived from other spatial sensors) in order to achieve a better understanding of these interactions and variables.

Disaster-environment-poverty cycle. The SIGA system is based on the simultaneous incorporation of physical-natural environmental factors (geomorphs, geology, hydrography, etc.) with social factors (poverty, income distribution and other socio-economic indicators) and institutional framework factors, in order to analyze the problem with a global vision and detect the poverty-natural resources degradation-disasters feedback cycles.

Integrality. The SIGA approach attempts to incorporate scientific-technical knowledge, popular wisdom and the experience of the various actors and social sectors (official organizations, civil society, the academic sector, enterprises), by means of the inclusion of information in its database, in spite of the varied origin of the information and the varying spatial scales to be included. In this sense, the SIGA offers a tool which goes beyond the technocratic and geophysical vision of disasters, including the knowledge of social science.

Participation. In keeping with the above and taking into account the processes of decentralization and—in some cases—the consolidation of democracy in municipal management which is taking place in the region, the SIGA approach contemplates and promotes the broadest participation of actors and sectors involved in the search for solutions to the problems involved in environmental management of the territory.

Transparency. The product generated through the SIGA allows all social actors to participate in its generation and have access to information. In consequence, it allows influence on decision-making, adapting to the realities and requirements of society, thus guaranteeing the transparency of municipal management. Furthermore, it promotes wider circulation of information on the levels of vulnerability of assets and, in general, on the whole system and the economic agents of the municipality.

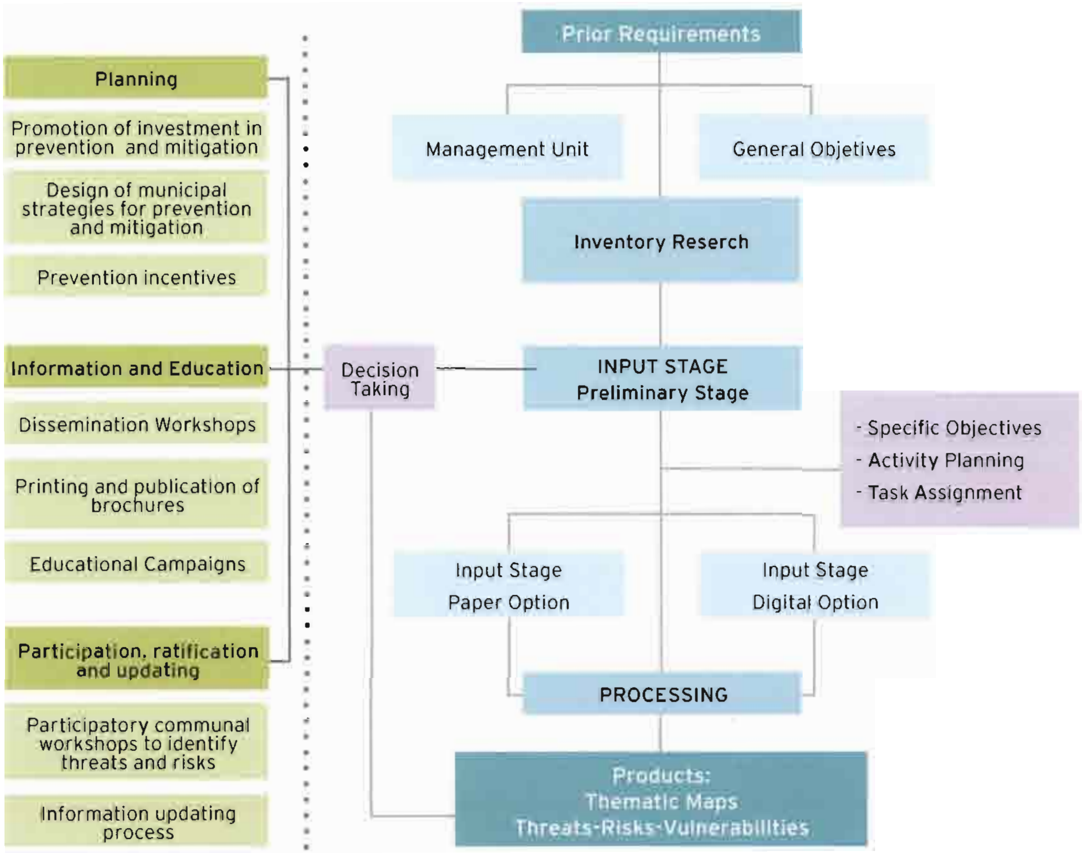
Continuity. The SIGA generation process takes time; its variables are dynamic, both temporally and spatially. Therefore, the SIGA anticipates continuous information updating mechanisms through the Information Management Unit and communal validation of these mechanisms by means of participatory workshops.

Aims of the Methodological Guide

To initiate municipal technicians in the discussion and manufacture of the SIGA, for which the various methodological phases proposed for setting up the SIGA (collection, input, processing and creation of indicators) must be complied with. These phases are exhaustively described in the Manual available on the Internet at www.idrc.ca/upe.

3. PHASES IN THE CONSTRUCTION OF THE SIGA

Chart 4. SIGA elaboration process



This Methodological Guide develops the different phases required for the implementation of the SIGA. The details are shown below:

It is important to keep in mind that the SIGA is a methodological tool that **generates products to nourish the decision-making process**, with the aim of reducing vulnerability and risk levels for the population, as well as for the municipality's assets.

The decision-making process depends upon the Local Government's type of structure, local interest groups, the government's perspectives, and the municipality's complexity and the challenges it faces. Therefore, the making of decisions at the planning and execution level is complex. It is not the intention of the SIGA to put forward the naïve notion that the mere availability of its products will make the planning process, even regarding prevention and mitigation, take place spontaneously. As the above diagram shows, this manual does not deal with decision-making process methodology. That is in itself a planning and decision process area which is beyond the scope of this manual.

However, the decision-making process, in this case applied to vulnerability and risk reduction, can be divided into decisions on:

Planning
Including evaluation and decision processes regarding the choice of investment in prevention and mitigation; the design of strategies at the municipal level for the execution and development of these investments and related activities, as well as the design of economic incentives to encourage investment patterns among municipal actors endogenously (for example, in commercial, industrial or domestic sectors, exchanging payment of municipal rates for preventive investment).

Information and Education

This process takes a selection of SIGA products and explains them in such a way that they will be understood according to the audience they are presented to (schools and other educational institutions, the general population, industrial managers, etc.).

Participation, validation and updating

The development of decision-making processes regarding the participatory validation and updating strategy is of utmost importance for the continuity of the services and the generation of effective SIGA products. To effect a pre-investment in the design of a SIGA may not be very profitable if the validation and updating effort is not kept up, since it will no longer be up to date and will not keep up with the dynamic nature of risk.

As the SIGA Elaboration Process Diagram shows (previous page) , other additional special interest areas may be added. Particularly significant is the focus the SIGA provides to generate decision-making processes regarding policy and strategy for the poorer or marginalized groups, so as to identify the important poverty-disasters-environmental degradation relation.

For illustrative purposes, examples are included at the end of this manual of how SIGA products may be used to nourish this decision-making process using indicators.

Prior Requirements

The SIGA is planned with the **capacity and flexibility** to adapt to different municipal realities, making the necessary adjustments to allow for existing levels of information, and the technological and human resources available in each municipality. It is clear, however, that some minimal elements are required for its installation, maintenance and operation.

Municipal Organizational Chart (Structure, Units, Committees)

To be familiar with the organizational structure of the municipality, in order to identify the services related to environmental management in general, and/or risk management in particular.

Table. 3. Tentative Chart Model

Municipality	Departament		
Personnel	Number	Level of Education	Staff Specialty or skills
Mayor			
Secretary			
Administrative staff			
Technics			
Clerks			
Otrhers			
Equipment	Number	Location	Equipment characteristics
Cartography			
Computers			
Machinery			
Executive Units	Number	Personnel Assigned	Field
Environmental Unit			
Cadastral Registtry			

Links with other Institutions

Permits knowledge of the institutional status regarding competencies, human and technical resources available, experience and levels of coordination with other departments of the municipality itself and external institutions.

Table 4.

Institutions	Units	Information Available
Central Government		
Departments		
Municipalities		
AMUNIC/ AMHON		
Universities		
NGOs		
Social Groups		
Others		

Information Management Unit (IMU)

The Information Management Unit will comprise technicians and administrators related to each municipal thematic area (technicians, managers). The tasks it carries out are the following:

IMU Duties:

- To gather and process the information required to generate the **SIGA**.
- To keep the system updated.
- To define the general and specific aims of the **SIGA.**
- To establish contacts with other governmental offices (other municipalities, ministries, head offices) and with social actors (NGOs, the academic sector and the business sector).
- To advise the municipal government on subjects directly related to threats, vulnerability, and environmental risk, as well as on the drawing up of the territory's environmental regulatory plans, if required.

It should be pointed out that the proposed IMU has no power of decision nor does it act as an emergency committee or any similar body in critical situations.

General aims of the implementation of the SIGA

The general aims of the implementation of the **SIGA** methodology should be established by the **Information Management Unit** in each municipality, keeping in mind the nature of the threat(s) and the vulnerable population potentially affected.

It is advisable to define short, medium and long term objectives. It is also necessary to establish goals linked to each objective, to monitor the process's progress and to evaluate its fulfillment.

Questions for IMU technicians to ask prior to the creation of the SIGA:

1 Which are the permanent or more frequent natural or social threats in the action area or surroundings of my municipality? What is their degree of intensity?

2 Which social groups (age, sex, economic level, etc.) and locations (city neighborhoods, small towns, villages, hamlets, etc.) are affected?

3 Which territories and infrastructures (road network, electric power grid, sewer systems, etc.) are damaged when this (these) threat(s) materialize(s)?

4 What resources (human, economic, technical) are currently available to my municipality in order to face these events?

5 How does my municipality organize itself when faced with these events? Is there usually coordination with neighboring municipalities or with other administrative levels (for example: Ministries)?

6 Is there coordination with local social organizations? If there is, how is it carried out?

7 What information must I have access to in view of the threat(s) indicated?

For example, in the case of floods: rainfall records, soil characteristics, use of soil, records of similar events, number of victims and affected people, risk perception on the part of the population which may be potentially affected, etc.

8 How and where can I obtain this information? If necessary, can my municipality generate it? How?

Definition of variables to be considered

The variables to be considered will depend upon the double threat-vulnerability elements in each municipal situation. Variables should be chosen which, in limited numbers, best define these elements.

Consideration of difficulties to be resolved

These difficulties may be external or internal to the municipality.

External difficulties are of various origins:

At the **political level**, if the decision makers are not willing to implement the **SIGA**, or if other priorities–be they national or municipal–are given precedence.
At the **administrative level**, if there is insufficient coordination among municipal offices related to environmental matters.
At the **technical level**, if indispensable human resources are lacking.
At the **economic level**, if a minimum budget is not assigned for the pre-investment required to develop and activate the SIGA operation.

Internal difficulties are related to the **SIGA** methodology itself. Its implementation will seek to overcome obstacles such as

- The **time** required for the manual input of information.
- **Incompatibility of scale** in the maps available, for the case of manual input; or **lack of information on a municipal scale.**
- The **choice of the appropriate software**, taking into account cost of access, its capacity to handle information and the operators' level of training.

Input Stage

Chart 5. Input Stage

Stage 1 - Geophysical System
i) Hydric Network
ii) Altimetry - Contour lines
iii) Basing boundaries
iv) Geology
v) Geomorphology
vi) Precipitations and temperature

Stage 2 - Socio-Economic System
vii) Social Variables
viii) Economic Variables
ix) Social Vulnerability Index

Stage 3 - Land Use
x) Municipal, urban and rural land use

Stage 4 - Lifelines and Services
xi) Drinking water supply, light and waste disposal network
xii) Basic public services

Stage 5 - Processing
xiii) Production of simple and complex indicators
xiv) Environmental Risk Maps

Basic Coverage in setting up the SIGA

Stage 1. Geophysical System

In this first–**Geophysical**–stage, information about the municipal territory is compiled, produced and entered: River basins and hydric networks (watercourses), land elevations (height of terrain), geology and soil.

This first unit allows the identification of areas frequently exposed to intense natural events, such as: floods, landslides and earthquakes, among others.

Stage 1. Geophysical System

National Boundary

Initial coverage. The Departmental Boundary is digitalized in it.

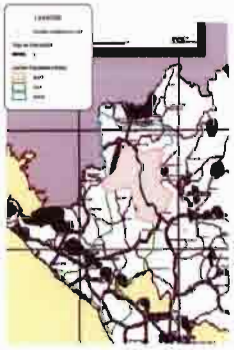
A general poligon is drawn with the boundary:

1- Departmental

2- Municipal

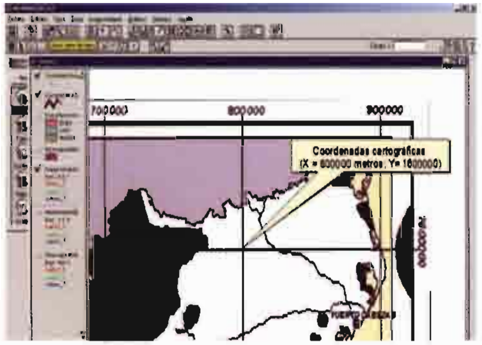
The system of coordinates is used by the national geographic service (cartographic coordinates: X, Y, Z)

It is necessary to work with the same system of coordinates on all maps, this allows the crossing of different coverages.



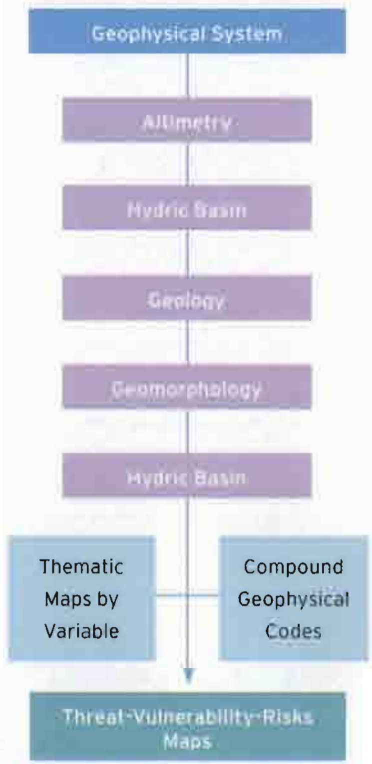
Municipal Boundary

Digitalization of poligon with the limit: national, departmental and municipal.



The municipal coverage will be used as a frame for future coverage.

Stage 1 - Geophysical



1- Basic data collection, production and input:

Minimum information required: relief, hydric network, geology and/or soil, geomorphology.

Each variable allows a thematic map to be created

Paso 1 - Hydric network
Paso 2 - Altimetry
Paso 3 - Hydric Basins
Paso 4 - Geology and/or Soils
Paso 5 - Geomorphology

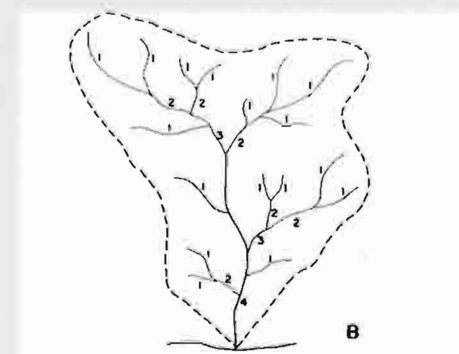
2- Cross-referencing of information is carried out according to external threats (climatic, sismic), to determine natural risk areas.

Paso 6 - Temperature and Precipitations

Basic Materials - Topographic map on a scale of 1/50,000, produced by the Geographical Service on paper and digitally (scanned)

Step 1 - Hydric Network.

Copy (digitize) the hydric network from the topographic map (Military Geographical Service, scale 1/50,000).



Hydric courses are carved into the territory, forming a Hydric Network. All of the territory that drains towards the same point is called a Hydric Basin. In order to analyse a basin, watercourses are organized in order of importance, according to their position in relation to the main watercourse. Observe the drawing and look for hydric networks in the topographic chart.

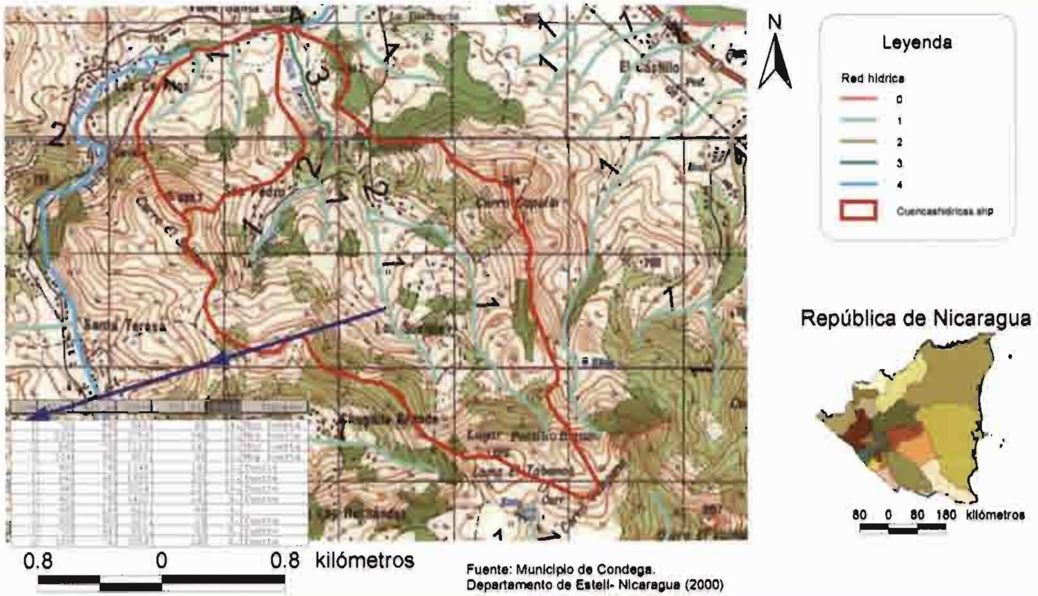
Watercourses originate in high areas (hills, mountains, etc.) and as they descend into the valley, they are joined by spring originated courses, making up larger watercourses known as hydric networks or drainage networks.

On topographic maps, watercourses are symbolized by means of blue dotted lines (-----) for creeks and intermittent streams or blue unbroken lines for streams and rivers (–––).

Digitization. Springs are drawn first, with the line mode tool.

- Digitization of the Hydric Network. Lines are drawn. Watercourse springs are drawn first, using the topographic map as a model. As shown in the picture, at the end of each river section, the program creates an **associated table**, to which the technician adds new fields in the shape of columns.

Fig. 2. Digitalization of the Hydric Network, using information from the 1:50.000 topographic chart of a hydric basin Río San Pedro. Municipio de Condega. Departamentode Estelí, Nicaragua



Associated Table to the Hydric Network coverage, to which fields (columns) are added with relevant information.

Atributos de Redhídrica.shp

Shape	Id	Orden	Lenght	Alt_m	Alt_min	Distan	Dif_alt	Pend
PolyLine	101	1	612.658602	0	0	612.7	0	0.0
PolyLine	101	1	2024.203965	940	720	2024.2	220	10.9
PolyLine	102	2	1113.283403	860	720	1113.3	140	12.6

Table 5.

ID

A field the program creates automatically. It is recommended that a code be used (ID - with a code of 100).

Order of Classification

The segments of the course are classified in order of importance. From the springs to the first tributary, the courses are classified as class 1. When two segments of an equal Class come together, the down-river segment is coded using a higher classification (Class 2). The Network is thus built up in order of importance. Normally, watercourses are Class 4 or 5. These segments are permanent in nature, whilst the Class 1 courses are intermittent (sporadic).

Maximum Elevation of Springs - Max_ Elev

This information is obtained from topographic charts, simply by reading the contour line which crosses it.

Minimum Elevation of Springs - Min_ Elev

This information is obtained from topographic maps, simply by reading the contour line which crosses it.

Length of the watercourse

Real distance covered by the watercourse. This operation is carried out by means of a program command (automatic distance calculation).

Slope (%)

The longitudinal slope gradient of the watercourse is calculated in segments. This information allows watercourses to be classified.

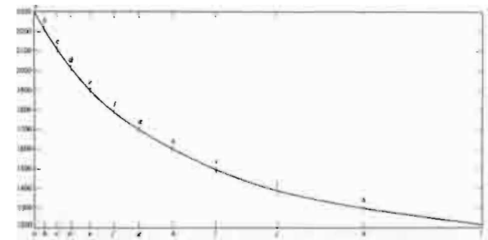
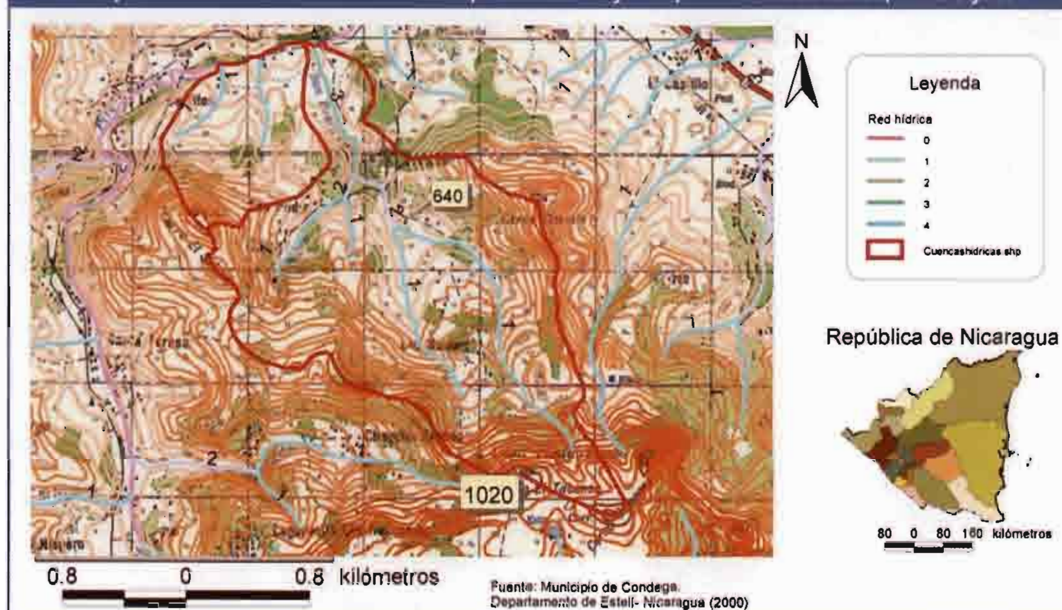


Chart 7.
Segment Slope Gradient (%) =
Altimetric Dif. (M_Ht - min_Ht)/length of segment x 100

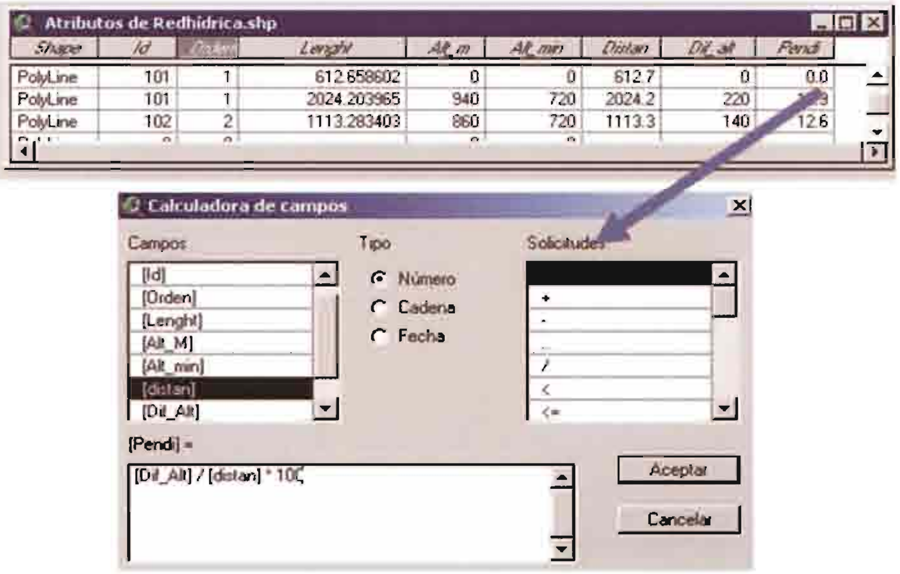
Fig. 3. Digitalization of the hydric network, using information from the 1:50.000 topographic map of a hydric basin. Río San Pedro. Municipio de Condega. Departmento de Estelí, Nicaragua.



Information about maximum and minimum elevations and length of watercourses is obtained from the topographic map, in order to complete the information and calculate slopes.

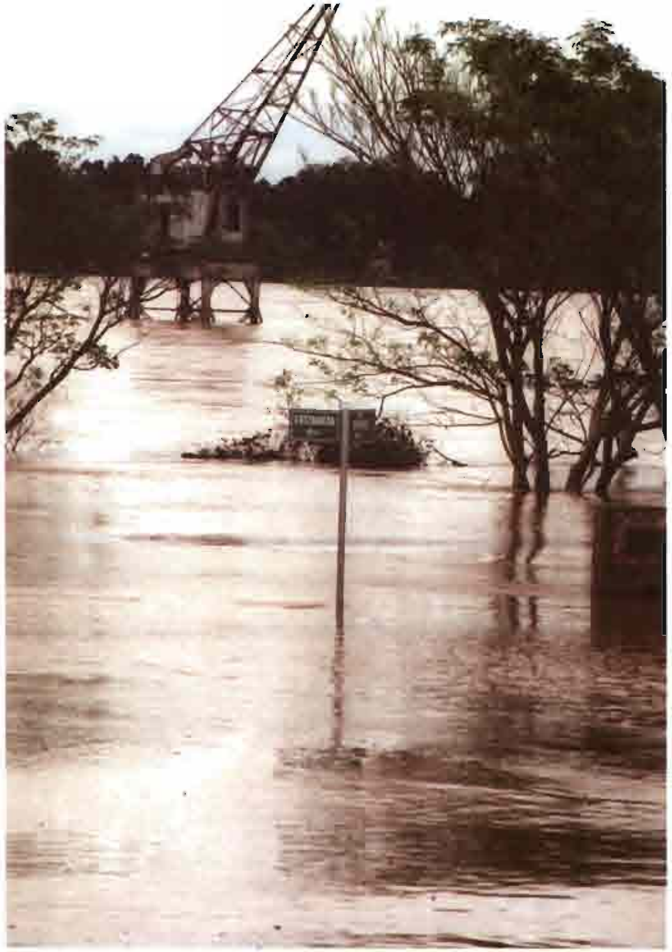
It is recommended that the table be built up gradually in an orderly manner, for each hydric network. This makes it possible to check the digitization process, correct errors and avoid information gaps.

Table 6.



Atributos de Redhidrica.shp

Shape	Id	Orden	Lenght	Alt_m	Alt_min	Distan	Dif_alt	Pendi
PolyLine	101	1	612.658602	0	0	612.7	0	0.0
PolyLine	101	1	2024.203965	940	720	2024.2	220	[illegible]
PolyLine	102	2	1113.283403	860	720	1113.3	140	12.6



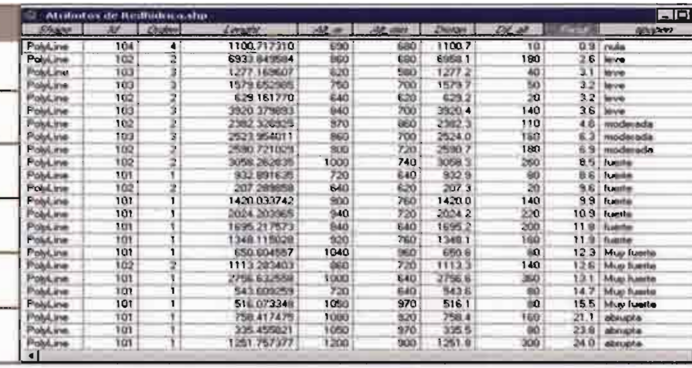
Classification of watercourse slopes by segment (field = slopetype)

In order to classify river slopes, it is only necessary to consult two tables in the manual:

1- Hydric Network,
2- Contours.

With the watercourses classified in order of importance and of slope, the first characteristic of the territory is obtained. Steep changes in slope are areas likely to suffer mud flow and landslides; particularly if the soil is claylike and with steep slopes.

Slope %	Slope Type
0-2	Very slight
2-4	Slight
4-8	Moderate
8-12	Steep
12-16	Very steep
Over 16	Sheer



Shape	[illegible]	Orden	Length	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PolyLine	104	4	1100.717310	690	680	1100.7	10	0.9	nula
PolyLine	102	2	6933.849584	860	680	6958.1	180	2.6	leve
PolyLine	103	3	1277.169607	620	580	1277.2	40	3.1	leve
PolyLine	103	3	1579.652985	750	700	1579.7	50	3.2	leve
PolyLine	102	2	629.161770	640	620	629.2	20	3.2	leve
PolyLine	103	3	3920.379893	840	700	3920.4	140	3.6	leve
PolyLine	102	2	2382.326325	970	860	2382.3	110	4.6	moderada
PolyLine	103	3	2523.954011	860	700	2524.0	160	6.3	moderada
PolyLine	102	2	2590.721029	900	720	2590.7	180	6.9	moderada
PolyLine	102	2	3058.262635	1000	740	3058.3	260	8.5	fuerte
PolyLine	101	1	932.891635	720	640	932.9	80	8.6	fuerte
PolyLine	102	2	207.289858	640	620	207.3	20	9.6	fuerte
PolyLine	101	1	1420.033742	900	760	1420.0	140	9.9	fuerte
PolyLine	101	1	2024.203965	940	720	2024.2	220	10.9	fuerte
PolyLine	101	1	1695.217573	840	640	1695.2	200	11.8	fuerte
PolyLine	101	1	1348.115028	920	760	1348.1	160	11.9	fuerte
PolyLine	101	1	650.604587	1040	960	650.6	80	12.3	Muy fuerte
PolyLine	102	2	1113.283403	860	720	1113.3	140	12.6	Muy fuerte
PolyLine	101	1	2756.632558	1000	640	2756.6	360	13.1	Muy fuerte
PolyLine	101	1	543.609259	720	640	543.6	80	14.7	Muy fuerte
PolyLine	101	1	516.073346	1050	970	516.1	80	15.5	Muy fuerte
PolyLine	101	1	758.417475	1080	920	758.4	160	21.1	abrupta
PolyLine	101	1	335.455821	1050	970	335.5	80	23.8	abrupta
PolyLine	101	1	1251.757377	1200	900	1251.8	300	24.0	abrupta

Table 7 and 8.

Figure 4. Landslide on steep hillside. Salta, Argentina. Colin, Thomas 2007.

Step 2. Altimetry. Copy the contours from the topographic map.

Contours are lines of equal height. Height is symbolized on topographic maps by means of dark and light-toned sepia lines. Dark contour lines, known as "master" or "main" lines, every 100 meters and "common" or "secondary" contours every 20 meters.

Digitization

Is begun along the closed contours representing higher areas. Use of the polygon tool or the line tool is recommended.

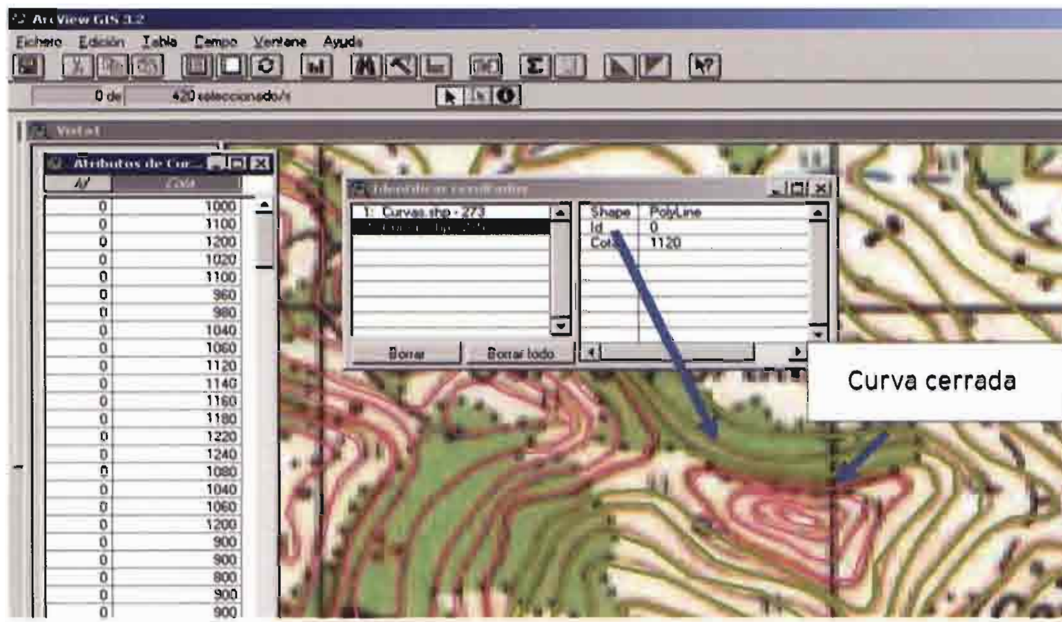
- When closing the contour polygon, the program creates an associated table, to which new fields (columns) containing the spot height of the terrain may be added manually.
- This coverage takes up a great deal of digitization time, so it is suggested that negotiations with a similar state organization should be undertaken in order to obtain it.
- Correction of digitization errors.

ID. Automatic Identification

Spot Height. The elevation of a contour, number of vertical metres above sea level; this information is obtained from the topographic map. Master or main contours every 100 meters.

Why is it useful to cover contour lines?

- To separate hydrographic basins, so that rainfall divisions may be identified.
- To calculate the gradient of watercourses and hillsides.
- As an input for a 3-dimensional model, if the appropriate program is available.
- To determine altimetric levels.
- Basic input for a thematic map of the main geomorphs, with the aid of aerial photographs.



Contours are digitized from the topographic map.

Figure 5.

Step 3. River Basins.

Draw the separation of the River Basins, using the watershed lines, with the help of the contours from the topographic map (scale: 1/50,000).

Basins, sub-basins or micro-basins may be identified, according to the hydric network determined by the watercourses.

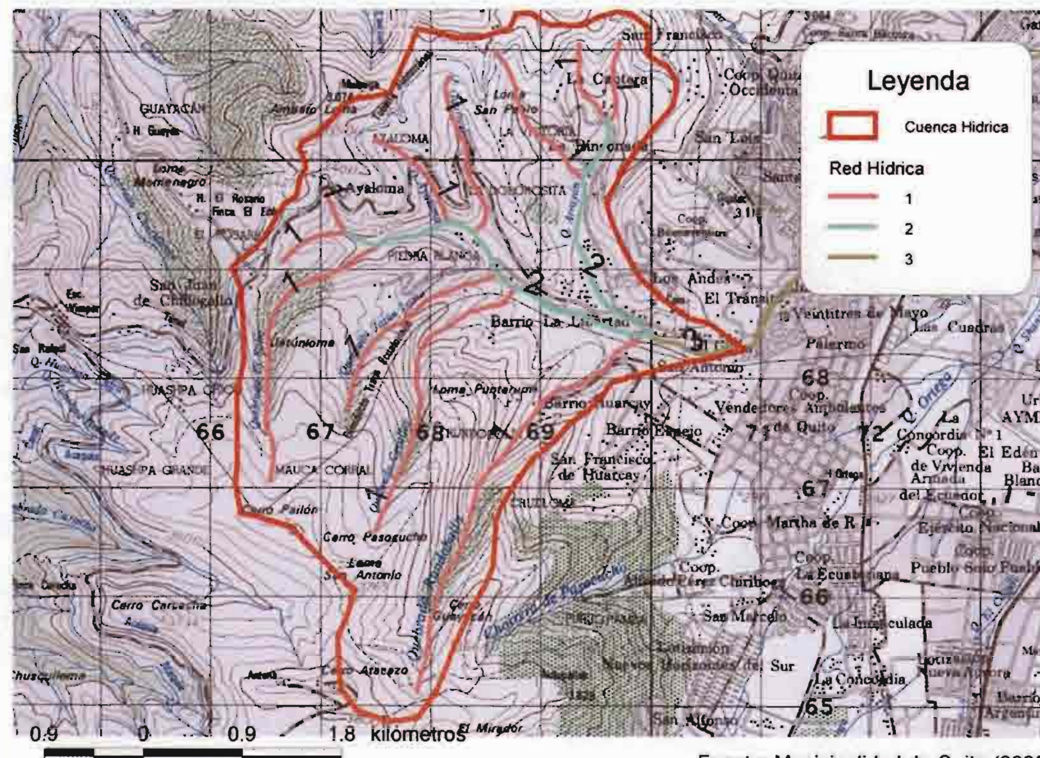
River Basins do not necessarily follow administrative boundaries, so it is imperative for the environmental management of the territory to work in conjunction with other municipalities inhabiting the basin.

Headwater basins are fragile areas, steeply sloped, and thus susceptible to erosion. Furthermore, low areas are naturally prone to flooding and outflows of mud.

> Digitization
>
> A polygon is created to cover the more elevated areas of the terrain.

In order to find the basin's boundaries, the drawing must cover the higher parts of the terrain. The closed contours are the elevated areas, where rainfall drains away in every direction; the centre of the contour is therefore taken as the boundary.

Fig. 3. River Basins

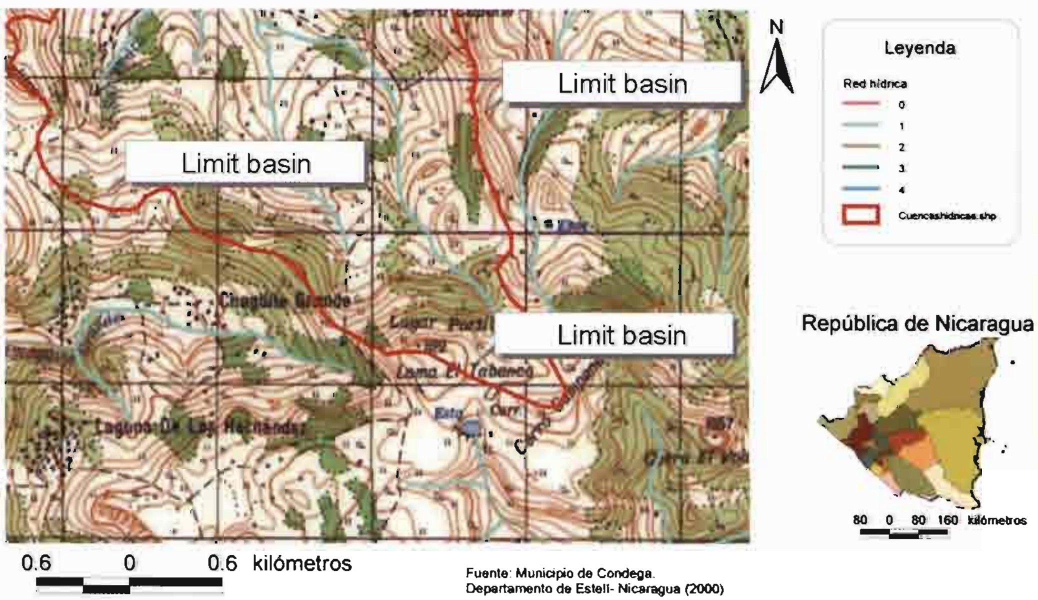


Fuente: Municipalidad de Quito (2005)

Study the picture above. Detail of the basin boundary outline, with contour lines.

Division of the territory into river basins facilitates the analysis of the water system's behavior, allowing calculation of surface runoff, infiltration and permeability, as well as water conservation status, when information about the use of land (urban and rural) is added.

Fig. 7. Detail of the tracing in a hydric basin
San Pedro River. Municipality Condega, Departament of Estelí, Nicaragua.



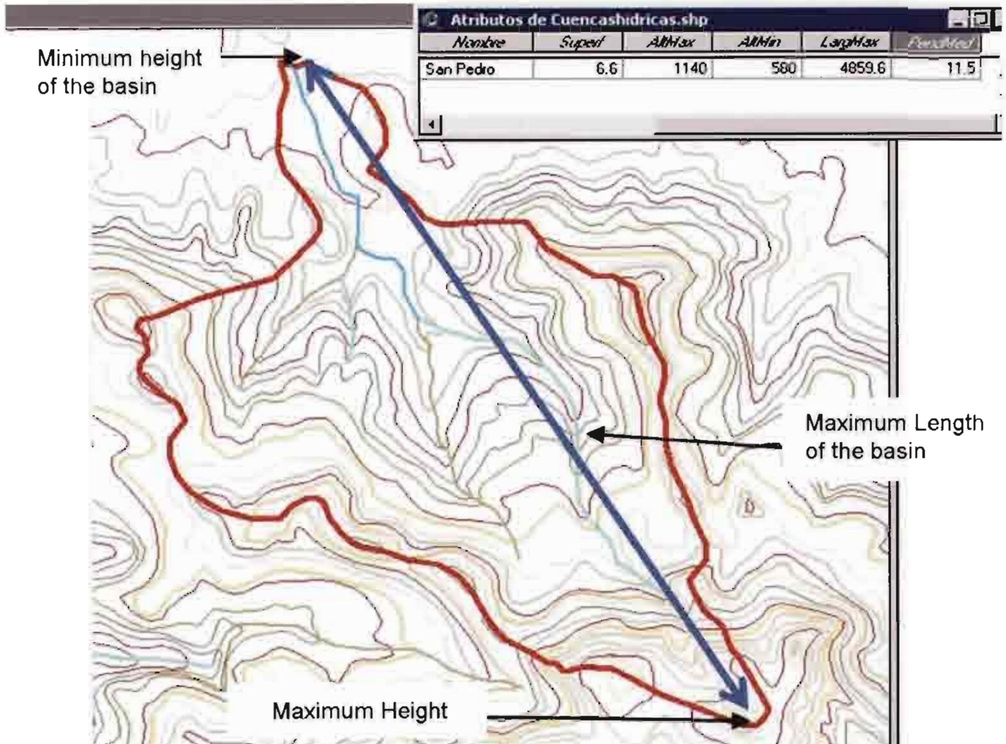


Table 9.

ID	Area	Area (Km^2)	Perimeter (Km)	MaxEl (meters)	MinEl (meters)	MaxLen (meters)	Average Slope (%)
300	San Pedro	6.6	13.135	1140	580	4859.6	11.5

Fig. 8. Data to be obtained from basins, sub-basins and micro-basins

ID
Identification code: 300

Area
This is automatically calculated by the program.

Perimeter
This is automatically calculated by the program.

Name
Name of the basin according to name of main watercourse

Maximum Elevation - MaxEl
Maximum Basin Elevation, the highest point of the watershed. Obtained from the topographic map.

Minimum Elevation - MinEl
Minimum Basin Elevation coincides with the height at the mouth of the main watercourse. Obtained from the topographic map.

Maximum Length - MaxLen
Maximum distance between headwaters and mouth of the watershed. Measured on the topographic map.

Mean Slope of Basin
Difference of elevation between maximum and minimum elevation of the basin, divided by maximum length.

Basin Slope (%) =
Height Dif. (MaxEl - MinEl)/length of basin x 100

This coverage provides knowledge of the basins and sub-basins which are most susceptible to erosion, landslides and avalanches.

Step 4. Geology

Input of existing geological information. Use of the geological map (scale: 1/ 100,000) is recommended.

Generally, the geological map is produced by state institutions. For example, in Nicaragua, it was produced by INETER. Usually, existing information is on a national scale (1/1,000,000; 1/500,000; 1/200,000). It should be pointed out that there is probably no detailed information on municipalities, but it is still possible to obtain an approximation of the municipal geological reality which may be improved upon with the contributions of other institutions (academic or ministerial).

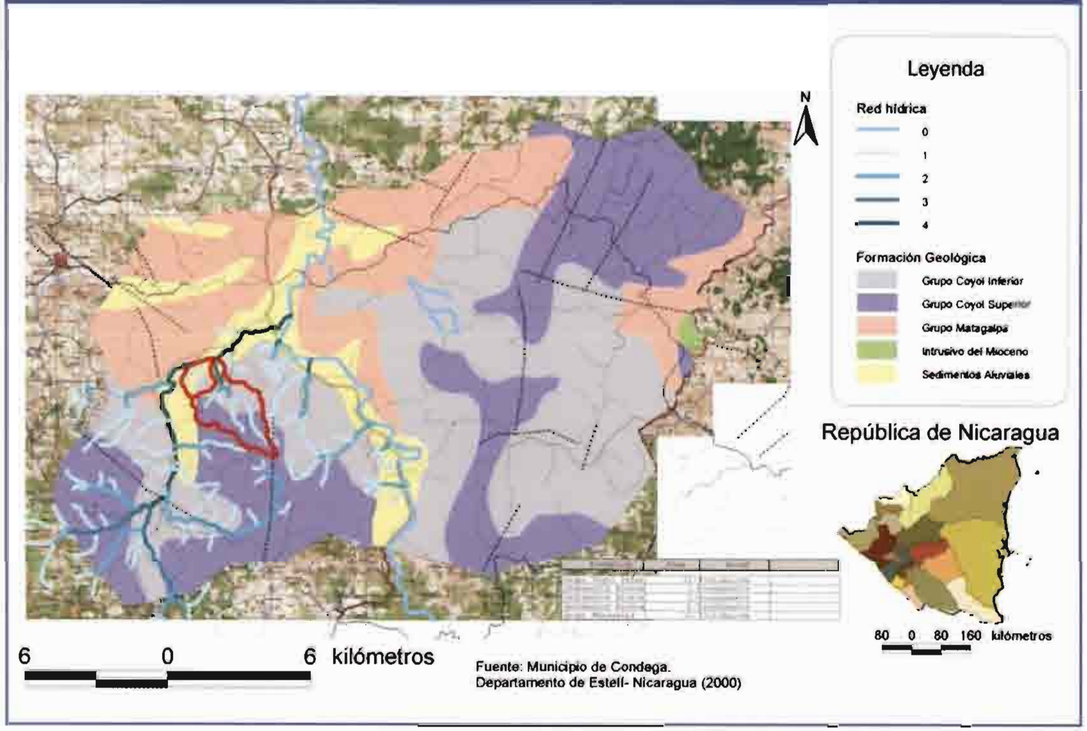
Basic Materials
Geological map (scale: 1/100,000 or 1/200,000) produced by a geological institution, on paper and digitally (scanned).

Digitization
Use of the polygon tool , the line tool or the dot tool is recommended.

Geological maps situate the main geological formations in the region. Reference to the predominant type of rock (igneous, sedimentary and metamorphic) is made in the captions. These maps also provide information about volcanoes and faults.

It is important to construct the polygons and complete the table columns with information about the rocks and the degree of alteration which can be concluded from the map's descriptive report.

Fig. 9. Geological Formations and Faults
Municipality of Condega, Estelí, Nicaragua

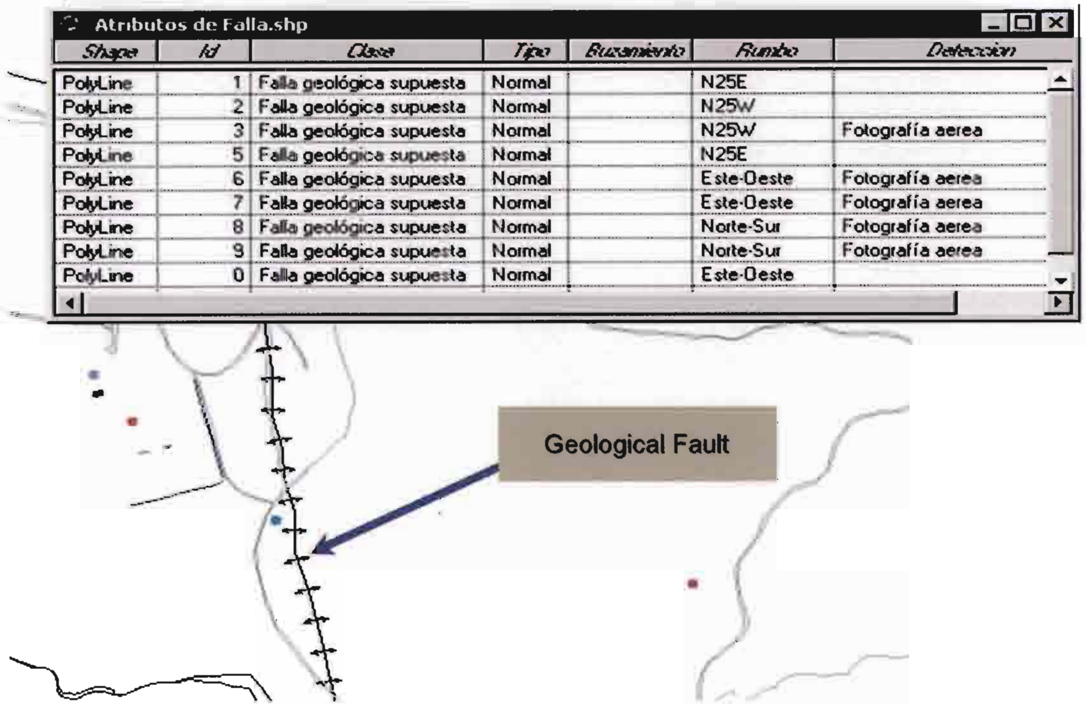


Faults

The line tool is used to digitize this coverage. Special coverage is produced. An associated table is created in which performance (active, passive) is registered.

When faults are located in urban areas, it is essential for the drawing up of regulations that building permit restrictions for public buildings (schools, hospitals, etc.) be anticipated.

Figure 10.



Shape	Id	Clase	Tipo	Buzamiento	Rumbo	Deteccion
PolyLine	1	Falla geológica supuesta	Normal		N25E	
PolyLine	2	Falla geológica supuesta	Normal		N25W	
PolyLine	3	Falla geológica supuesta	Normal		N25W	Fotografía aerea
PolyLine	5	Falla geológica supuesta	Normal		N25E	
PolyLine	6	Falla geológica supuesta	Normal		Este-Oeste	Fotografía aerea
PolyLine	7	Falla geológica supuesta	Normal		Este-Oeste	Fotografía aerea
PolyLine	8	Falla geológica supuesta	Normal		Norte-Sur	Fotografía aerea
PolyLine	9	Falla geológica supuesta	Normal		Norte-Sur	Fotografía aerea
PolyLine	0	Falla geológica supuesta	Normal		Este-Oeste	

Fallas geologicas del Municipio de Esteli, Nicaragua

Volcanoes

Description of the volcanic structures (cones, chimneys) and their activity, as well as the location of monitoring stations.

Maintaining direct contact and requesting support from the organization responsible for disaster prevention is recommended, since they will have the information and technical personnel required.

Step 4. Soil.

Input information from existing Soil map. It is possible that this map will have been produced by the Ministry of Agriculture, Livestock and Fisheries, or by soil management offices of the countries in question. The basic soil map may be at a 1/100,000 scale.

Basic Materials - Soil map (scale: 1/100,000 or 1/200,000) produced by a geological institution, on paper and digitally (scanned).

In this example, the soil map was produced by INETER and the land registry office. It should be pointed out that it does not contain detailed information for the municipality, but provides an approximate idea of the territory. As with the geological map, there is probably no map in existence with greater detail (1/50,000). Knowing the structure and properties of the soil will permit the detection of the more fragile areas of the terrain, with the greatest risk of landslides and erosion.

Digitization

The polygon mode is recommended .

Soil maps represent the types of soil, their classification and the materials that compose them (sand, mud, clay), which is known as texture. Soil texture depends on the originating material, the terrain's slope and age.

Figure 11.

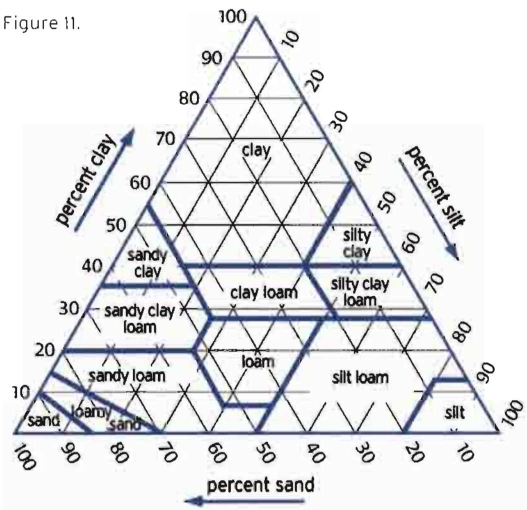
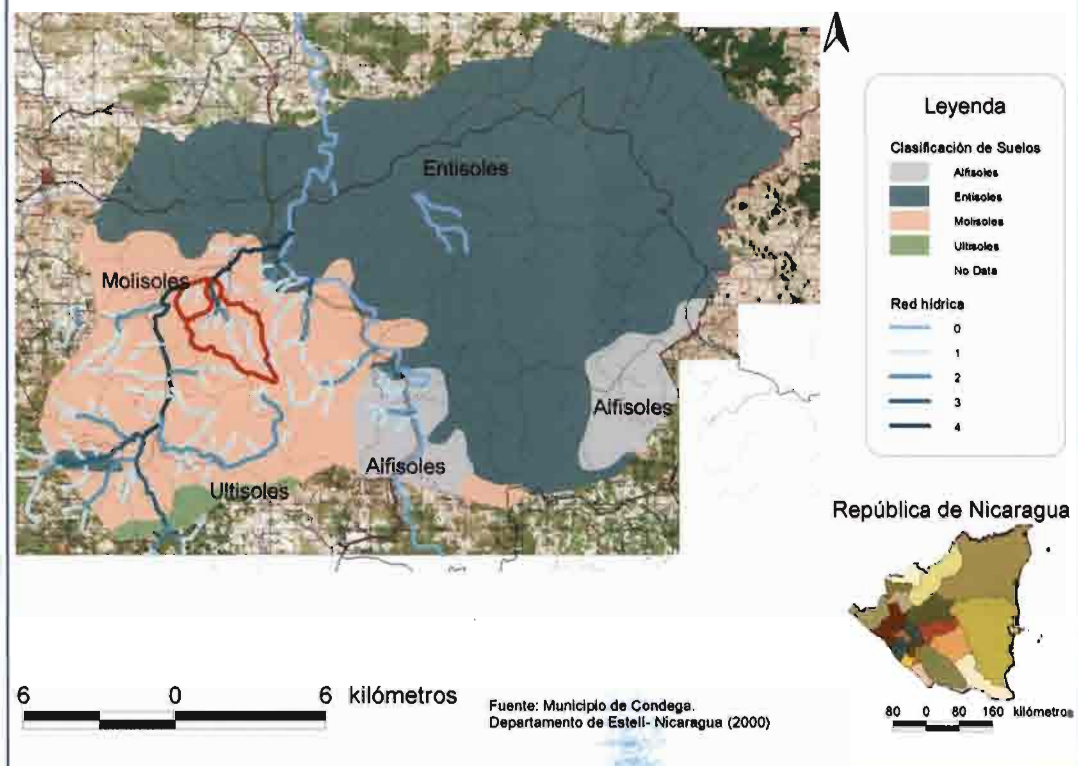
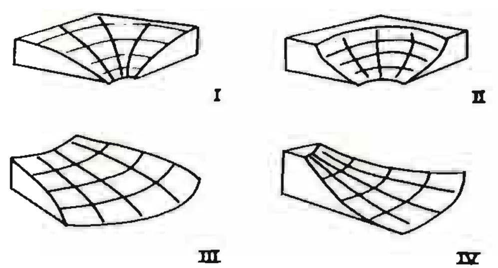


Chart showing the percentages of clay, silt, and sand in the baxic textural casses.

Fig. 12. Types of soils
Municipality of Condega, Department of Estelí, Nicaragua



Step 5. Geomorphology



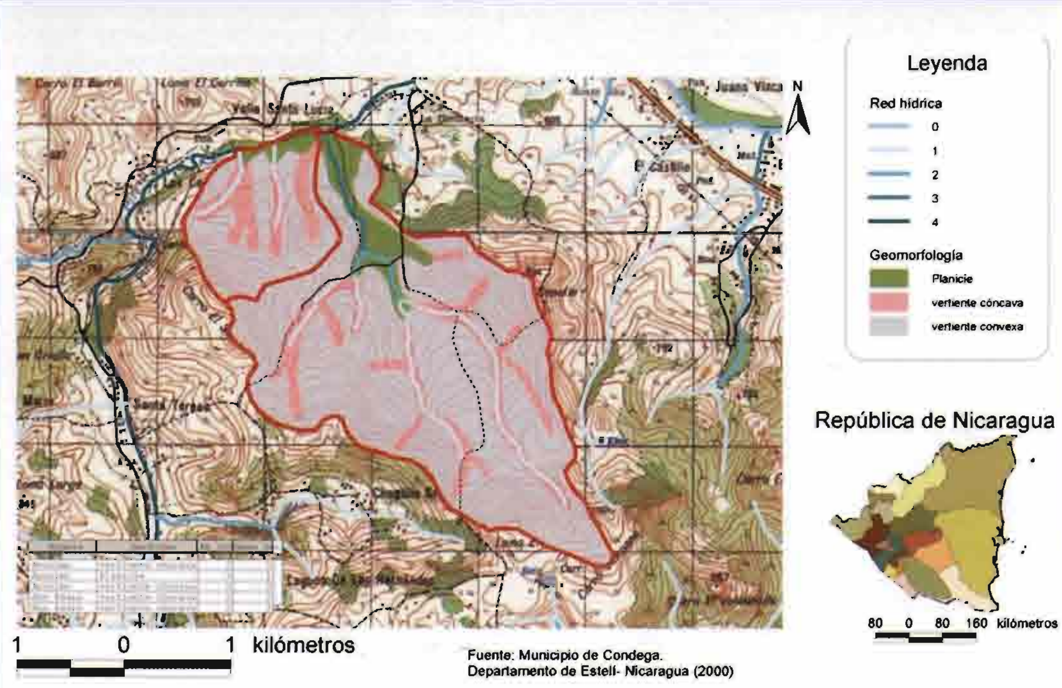
The geo-morphological map is created by the municipal technician, who uses a topographic map and photo-interpretation if there are aerial photographs available. The method is not exact. Information may be adjusted by means of field trips and interviews with local inhabitants.

Table 10.

Four basic types of slope, combining concavity and convexity (Troeh, 1965)	
Class I	Slopes with convex radii and concave outline
Class II	Slopes with concave radii and concave outline
Class III	Slopes with convex radii and convex outline
Class IV	Slopes with concave radii and convex outline

Basic Materials. Topographic map on a scale of 1/50,000 produced by the Geographical Service on paper and digitally (scanned).

Fig. 13. Major geoforms. San Pedro River Basin
Municipality of Condega, Department of Estelí, Nicaragua

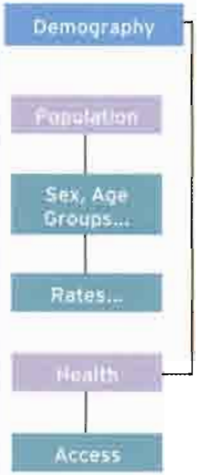


Stage 2

Socio-Economic System

These units include demographic, housing, welfare and human development information, as well as information about economic and production loss. As in previous units, they also require the use of variables to estimate the status of each of these sectors

Sub-stage 2.1 - Demography and Health



Processing of censal data: For greater analytical convenience, it is recommended to deal with these two aspects simultaneously, although they could aslo be dealt with separately.

Minimum information required: population numbers (sex, age groups), health coverage.

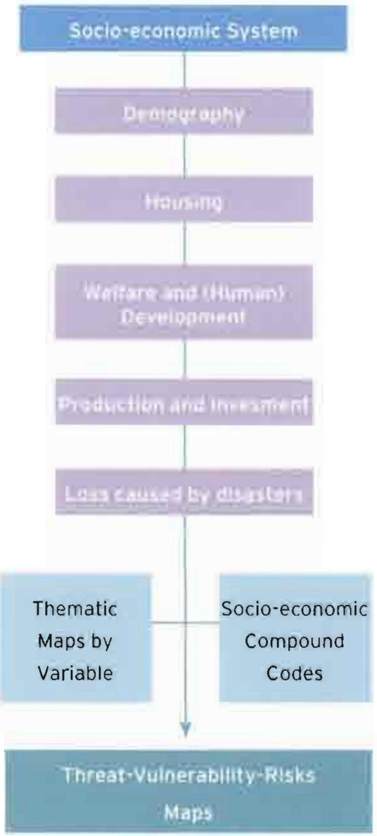
Step 1 - Censal cartography and codes.

Step 2 - Demographic information (population by sex, age groups, density, health coverage)

Step 3 - Other possible demographic and health indicators.

Chart 9.

Chart 8.



Step 1. Census coverage and codes

In most countries there is an institution which is responsible for population statistics. For example, in Nicaragua, the INEC (Spanish acronym of the National Statistics and Census Institute) produces a special collection of maps used to design Population Censuses. It divides the country into Censal Units (departments, municipalities, districts, neighbourhoods, communities), each identified by its own censal code.

Example: 0401001002003 - this code is assigned to a block located in the city of Estelí, in the municipality and department of the same name.

Fig. 14 and Table 11.

Department	Municipality	Censal Code Municipal	District Censal	Neighborhoods	Communities
Managua (01)	Managua (01)	0101	001	001 002	001 002
Estelí (04)	Estelí (01)	0401	001 999	001 002 999	001 002 003 ... 999

Censal information may be obtained directly from INEC. Censal maps are added to the SIGA, and a table is produced with matching codes.

Each municipality chooses the territorial scale to work with (neighborhoods, segments or districts), and the census information is then included. The choice of scale is strongly determined by the availability of information at that level, in this as well as in other SIGA units.

Basic materials - Censal information in digital format (electronic spreadsheets) with the corresponding censal codes. Maps with neighborhood, segment and district boundaries.

Sub-stage 2.1 Demography and Health

Working with Data

Digitization

Existing databases are pasted. See pasted tables in ArcView.

Input of available censal data on paper. Charts are produced by copying data by variable and processed independently. In this variables unit, the Censal Unit must be kept very firmly in mind. It may be a District (less detail, easy access); a neighborhood/community (medium degree of detail and accessibility); or a city block or quadrant (greater detail, access limited by cost and volume of information). Availability of data at the Censal Unit level depends on the national statistics institutions; for example, in the case of rates, they are generally estimated by district. It is also possible to request the statistics and census institution to prepare data based on census information.

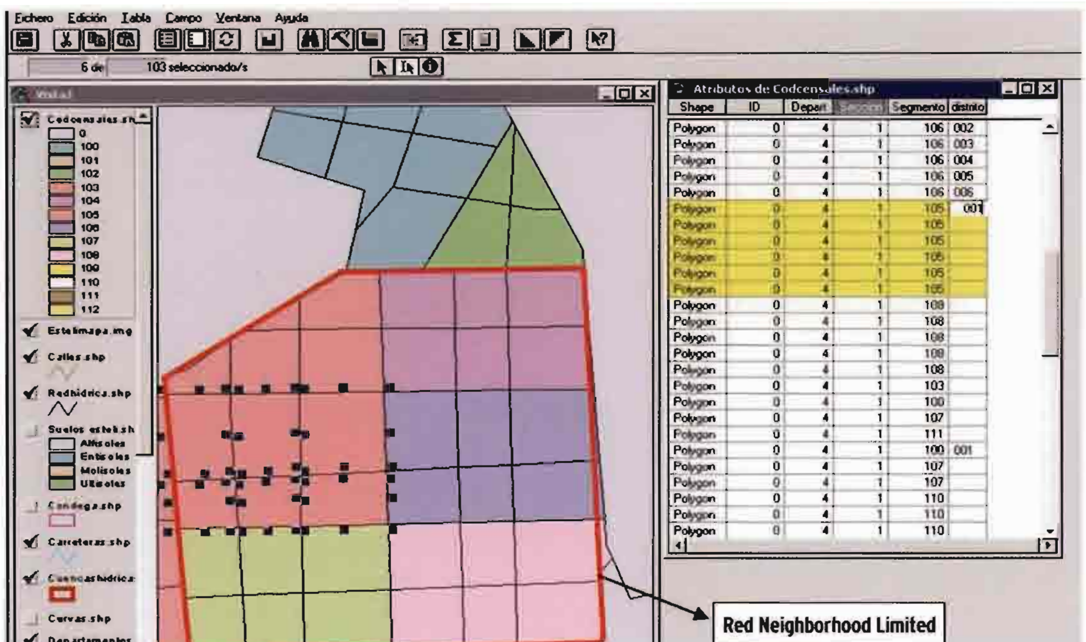


Figure 15.

As may be observed below, the health variable has been included within the group of variables typifying the demographic situation. This may be convenient when it is desirable to relate the state of the population's health directly, as shown in the following table.

Data generated by statistics and census institutions may usually be acquired and used as basic information in municipal management. For example, INEC - Nicaragua has some information available on their website and other information for sale at http://www.inec.gob.ni/productoscostos.htm. In Costa Rica, the website is http://www.inec.go.cr, in Bolivia, http://www.ine.gov.bo, and so on.

Demographic Variables to be Used	Operations to be Carried Out
POPULATION (See appendix)	
Number of inhabitants (urban-rural areas)	Population density (inhabitants/area)
Number of inhabitants by sex	Men/Women ratio (%) (Nº of men/Nº of women x 100)
Number of inhabitants by age group (children 0 to 12 years, adults 13 to 65, older adults over 65)	Age groups/total population considered (district, neighbourhood/community, city block) Nº of children / total inhabitants x 100 Nº of adults / total inhabitants x 100 Nº of older adults / total inhabitants x 100
HEALTH **Access to health coverage by type of service** (public, private coverage, no coverage)	Nº of inhabitants with access to medical care (state social security) / Total population considered x 100 Nº of inhabitants without access to medical care / Total population considered x 100
RATES Demographic Dynamics Birth rate (by sex) Fertility Mortality (by age and sex)	

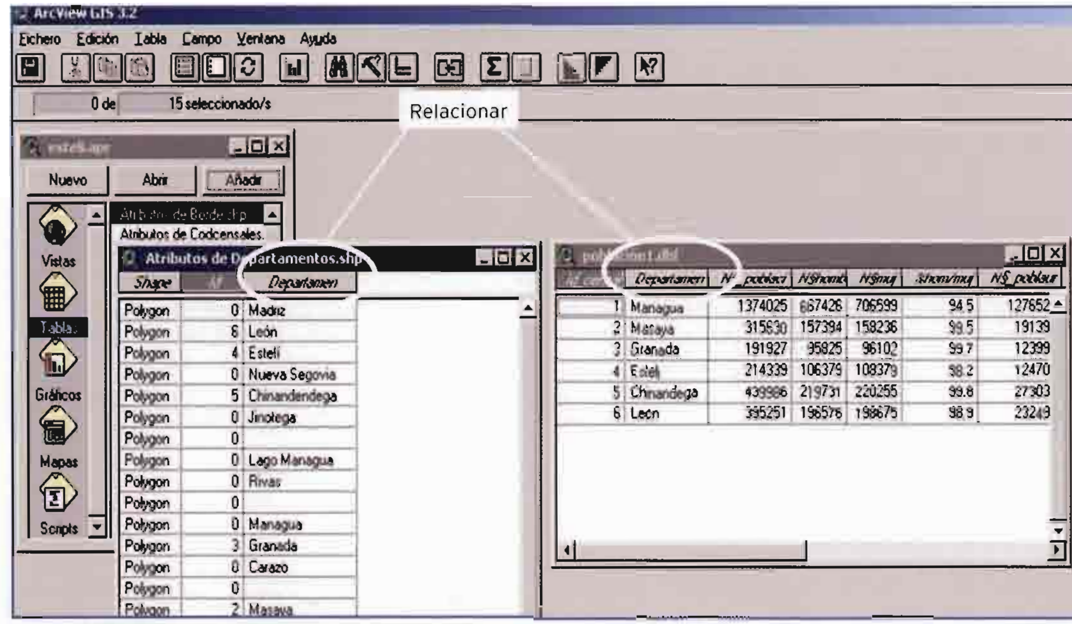
Table 12.

Production of Tables

Important. Tables may be prepared outside the SIGA, if information is available on paper or if it is digitized on electronic spreadsheets. Averages or proportional rates are calculated and finally, they may be organized in ranges.

Id_censal	Depart-ment	% Chil-dren	% Adult	% Aged
1	Managua	36	60,8	3,2
2	Masaya	39,6	57	3,4
3	Granada	40,4	55,8	3,8
4	Estelí	38,9	57,8	3,3
5	Chinan-dega	42,3	54,3	3,4
6	León	39,6	56,9	3,6

Table 14. Population data from latest Census -Distribution by Department- Taken from INEC, Nicaragua. 2001.



Figu. 16. Distribution of Children Population by Department.

Id_censal	Department	Nº population	Nº men	Nº women	% men/women
1	Managua	1374025	667426	706599	94,5
2	Masaya	315630	157394	158236	99,5
3	Granada	191927	95825	96102	99,7
4	Estelí	214339	106379	108379	98,2
5	Chinandega	439986	219731	220255	99,8
6	León	395251	196576	198675	98,9

Data copied from INEC-Nicaragua.

Processed Data

Preparation of basic demographic maps

Maps containing the municipal boundaries are prepared, including associated tables. It is essential to include a column containing the **censal codes** corresponding to **departments, municipalities, districts (censal sections), neighborhoods (censal segments) and communities**, so that the data may be geographically identifiable.

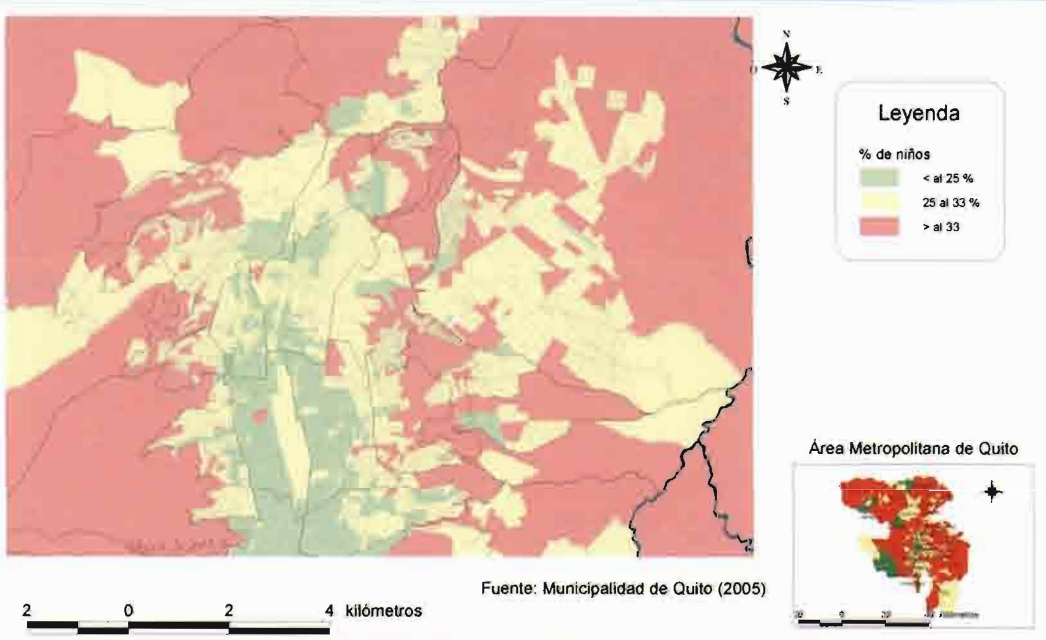
Production of other demographic indicators

In general, it is useful to produce other indicators related to the demographic situation and reflect them on a map. **There are two possible ways of doing this:**

A. Qualitative codification, in which a number can be assigned to codify a condition, for example, 1 if the variable is inferior to the mean, 2 if it is equal and 3 if it is greater than the mean.

B. Quantitative codification, in which the indicator may be specific to a single variable or composed of more than one variable.

Fig. 17. Distribution of Children below 15 years of age in Municipality of Quito

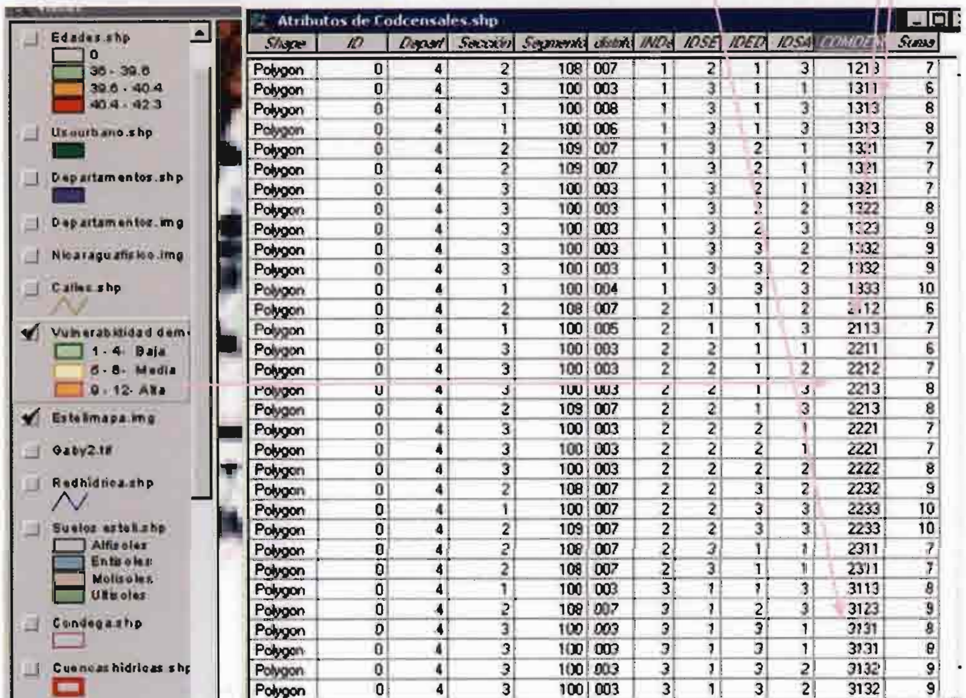


An example is shown below of qualitative codification. Later the production of simple quantitative indicators will be studied in depth and several examples will be given.

Table 15.

Some Demographic Indices	Category Construction	Value (code)
Neighbourhood density/Average city density Neighbourhood density/District density Block density/Neighbourhood density	Low: below average	1
	Medium: equal to average	2
	High: above average	3
Relationship according to gender (women/men)	Low: below average	1
	Medium: equal to average	2
	High: above average	3
Relationship by age group Children/Adults Children + older adults/Adults	Low: below average	1
	Medium: equal to average	2
	High: above average	3
Relationship by age group Population without medical coverage / Population with coverage	Low: below average	1
	Medium: equal to average	2
	High: above average	3

D	S	E	S	Possible Results
1	1	1	1	1111-1112-1113-1121-1122-1123-1131-1132-1133-1211-1212-1213-1221-1222-1223-1231-1232-1233-1311-1312-1313-1321-1322-1323-1331-1332-1333
	2	2	2	
	3	3	3	
2	1	1	1	2111-2112-2113-2121-2122-2123-2131-2132-2123-2211-2212-2213-2221-2222-2223-2231-2232-2233-2311-2312-2313-2321-2322-2323-2331-2332-2333
	2	2	2	
	3	3	3	
3	1	1	1	3111-3112-3113-3121-3121-3123-3131-3132-3133-3211-3212-3213-3221-3222-3223-3231-3232-3233-3311-3312-3313-3321-3322-3323-3331-3332-3333
	2	2	2	
	3	3	3	



Shape	ID	Depart	Sección	Segmento	[illegible]	IND	IDSE	IDED	IDSA	[illegible]	Suma
Polygon	0	4	2	108	007	1	2	1	3	1213	7
Polygon	0	4	3	100	003	1	3	1	1	1311	6
Polygon	0	4	1	100	008	1	3	1	3	1313	8
Polygon	0	4	1	100	006	1	3	1	3	1313	8
Polygon	0	4	2	109	007	1	3	2	1	1321	7
Polygon	0	4	2	109	007	1	3	2	1	1321	7
Polygon	0	4	3	100	003	1	3	2	1	1321	7
Polygon	0	4	3	100	003	1	3	2	2	1322	8
Polygon	0	4	3	100	003	1	3	2	3	1323	9
Polygon	0	4	3	100	003	1	3	3	2	1332	9
Polygon	0	4	3	100	003	1	3	3	2	1332	9
Polygon	0	4	1	100	004	1	3	3	3	1333	10
Polygon	0	4	2	108	007	2	1	1	2	2112	6
Polygon	0	4	1	100	005	2	1	1	3	2113	7
Polygon	0	4	3	100	003	2	2	1	1	2211	6
Polygon	0	4	3	100	003	2	2	1	2	2212	7
Polygon	0	4	3	100	003	2	2	1	3	2213	8
Polygon	0	4	2	109	007	2	2	1	3	2213	8
Polygon	0	4	3	100	003	2	2	2	1	2221	7
Polygon	0	4	3	100	003	2	2	2	1	2221	7
Polygon	0	4	3	100	003	2	2	2	2	2222	8
Polygon	0	4	2	108	007	2	2	3	2	2232	9
Polygon	0	4	1	100	007	2	2	3	3	2233	10
Polygon	0	4	2	109	007	2	2	3	3	2233	10
Polygon	0	4	2	108	007	2	3	1	1	2311	7
Polygon	0	4	2	108	007	2	3	1	1	2311	7
Polygon	0	4	1	100	003	3	1	1	3	3113	8
Polygon	0	4	2	108	007	3	1	2	3	3123	9
Polygon	0	4	3	100	003	3	1	3	1	3131	8
Polygon	0	4	3	100	003	3	1	3	1	3131	8
Polygon	0	4	3	100	003	3	1	3	2	3132	9
Polygon	0	4	3	100	003	3	1	3	2	3132	9

Table 15 shows the possible combinations when demographic variables are inter-related: density, sex, ages and health.

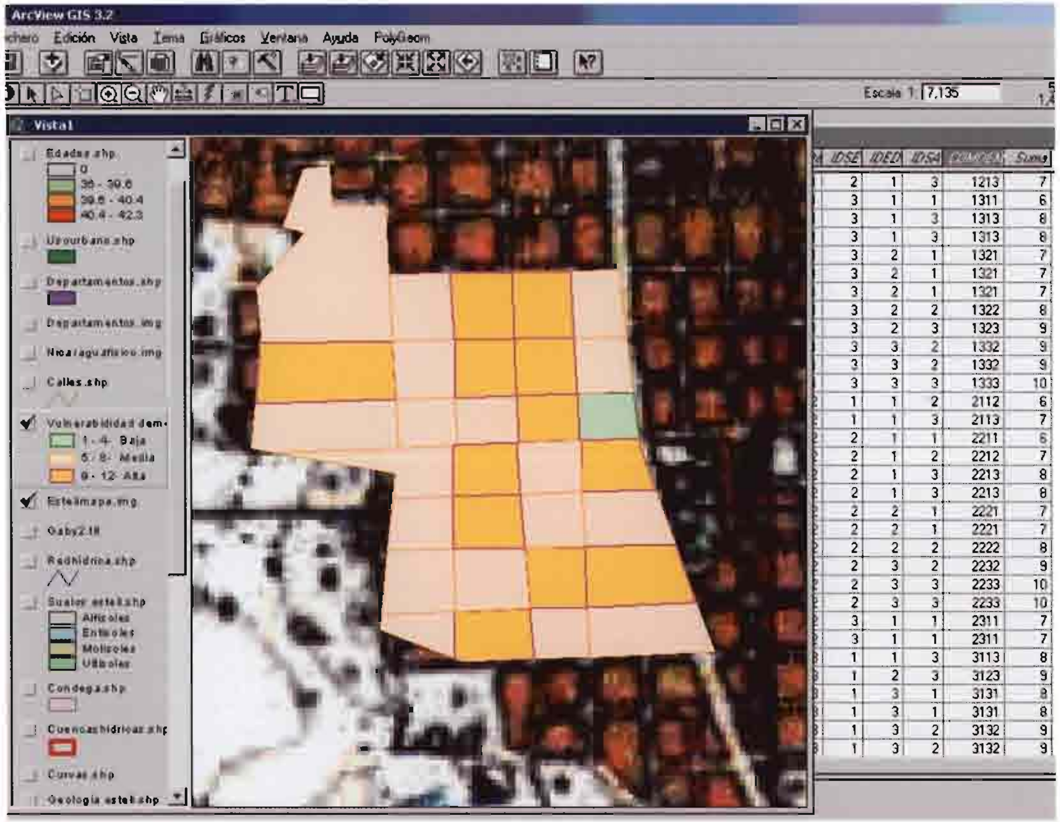
Demographic Information table
Each column corresponds to a variable (density, sex, age group, health coverage). In this example, the spatial distribution of these variables is analyzed for each quadrant in the city.

With this information, a summary of the demographic situation is generated using the previously codified variables, (according to the result of the addition of codification 1, 2 and 3, displayed in the column "Total").

In this example, the larger the result of the addition (closest to 12), the greater the social interest of the block (that is, denser, with a greater proportion of children and adults and a smaller rate of access to safety). **In that sense, it is identified as a relatively vulnerable group of inhabitants, from the demographic point of view.** It must be kept in mind that this does not mean that in absolute terms there are more inhabitants nor more children or older people living in the quadrant.

The map on the next page provides information on the social and economic vulnerability of those quadrants, in particular, their density, age groups by sex and access to medical social security.

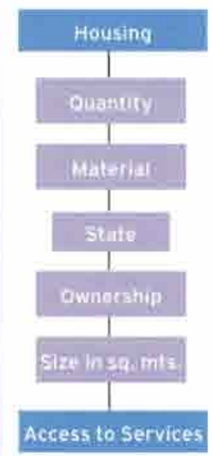
Figure 18. Map of the demographic situation for the city of Estelí, by city block.



Sub-stage 2.2.Housing

Step 1. Housing information.

Chart 10. Sub-stage 2.2. Housing



Step 1 - Information about housing: at least, number of dwellings; a description of materials and current condition would be very desirable.

Step 2 - Other possible information about materials, condition of dwelling, ownership status, size and access to services.

Variables are introduced in exactly the same way as in the case of "demography". As it has already been explained, greater geographical detail is linked to greater cost of information (district; neighborhood/ community; quadrant) or city blocks.

Censuses record valuable information related to housing at the Censal Unit level; in particular, their number, sometimes their condition (good, medium, poor), and ownership status (owned, rented, borrowed). Another significant source of information on housing is provided by income and expenditure surveys which these entities carry out, although usually the spatial resolution of these surveys is of a far more aggregate nature than in the case of a census.

Step 2. Other possible information on housing.

In the case of "housing", there is detailed information available in the records of municipalities. Although they may be outdated, they provide valuable information about the size in square metres of houses, types of building materials and access to services (municipal services, at least).

The following provides an example of possible variables to include.

As before, these variables may be used in a similar manner to previous cases.

Housing Variables to be Used	Operations to be Carried Out	Demographic Variables to be Used
QUANTITY		Access to services
(minimum level of data)	Nº households per censal unit	
		Water
MATERIALS		Good water (BAGUA)
Concrete	Nº concrete husehoIds/total households x 100	Poor water, rural area (MRGUA)
Wood		Poor water, urban area (MUAGUA)
Tin, cardboard	Nº wood husehoIds/total households x 100	
Mixed	Nº tin and carboard households/total households x 100	Sanitation
		Latrine
CONDITION		Toilet connected to sewage (CONAGNE)
Good Walls (BPARED)	Nº good households/total households x 100.	Toilet not connected to sewage (SINAGNE)
Poor Walls (MPARED)	Nº poor households/total households x 100	
Good flooring (BPISO)	Nº owned households/total households x 100	Gerbage Collection services
Poor flooring (MPISO)	Nº rented husehoIds/total households x 100	
Good roof (BTECHO)	Total sq.mts/total households x 100	Access to electric light
Poor roof (MTECHO)		Public Lighting
		Others
OWNERSHIP	Total sq. mts. Poor husehoIds/total households x 100	Access to hydrants
Owned		
Rented		
Let	Nº households with water/total households x 100	
Lent and others	Nº households with electricity/total households x 100	
SIZE		
Average size house		
Average size good house	Etc.	
Average size poor house		

Table 15.

Step 3. Other indicators of possible interest

It may be necessary to produce other demographic and housing indicators and/or to relate them. In these cases, the qualitative method can also be used (greater than, lesser than, equal to a datum, for example) and classification can be carried out in the same three categories. Later, the indicators are coded numerically (low - 1; medium - 2; high - 3), as previously explained. An example is given in Table 16.

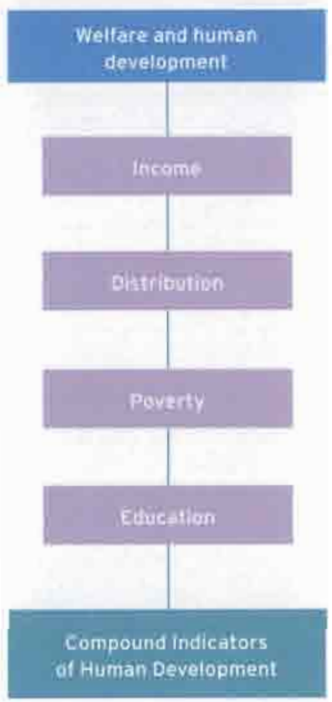
Many of the opportunities to create variables depend—once again—on the availability of information or on the budget available for obtaining this information in the field.

Other Demographic and Housing Indices	Categories	Value
Neighbourhood density/Average city density Neighbourhood density/District density Block density/Neighbourhood density	Low: Below average Medium: Equal to average High: Above average	1 2 3
Relationship by gender (women/men)	Low: Below average Medium: Equal to average High: Above average	1 2 3
Relationship by age group Children/Adults Children + people of age/ Adults	Low: Below average Medium: Equal to average High: Above average	1 2 3
Relationship Population without medical insurance/Population with insurance	Low: Below average Medium: Equal to average High: Above average	1 2 3
Relationship Bad quality housing/Good quality housing	Low: Below average Medium: Equal to average High: Above average	1 2 3
Housing with/without water	Low: Below average Medium: Equal to average High: Above average	1 2 3
Housing with/without electricity	Low: Below average Medium: Equal to average High: Above average	1 2 3
Maps according to compound variables	Categories Low Medium High	Code Minimum: 7 Medium: 14 Maximum: 21

Table 16

Sub-stage 2.3. Welfare and Human Development

Chart 11. Sub-stage 2.3. Welfare and Human Development



Although information about welfare and human development of the population is highly relevant, because it is economic information obtained from economic indicators, it cannot always be obtained in the desired spatial detail. In general, National Statistics and Census Institutes calculate several of these indicators. To do this, they regularly carry out income and household expenditure surveys, censuses, etc. This information is available for use, in accordance with the institution´s data policies. These indicators also appear in research carried out for university graduation papers.

Step 1. Data verification. Determine availability of information on welfare and human development. A minimum of information regarding income and poverty is required.

Step 2. Selection of indicators to be used according to quality and availability.

Step 3. Production of composite indicators.

This unit has been included in answer to the imperative need to determine the principal inter-connections in the reinforcement of the poverty-disasters-environmental degradation cycle, according to the Kobe Summit recommendation. Its careful structuring provides ample potential for contributing to the reduction of the vulnerability of the inhabitants of a municipality and the generation of greater resilience.

Step 1. Data verification. Go to the statistics and census institution, analyze the availability of indicators on human welfare and development and their geographic coverage. It is more and more usual to find these indicators at district levels and it will be difficult to find them at the level of neighbourhoods or communities. If you cannot find them, you may still consult the statistics bureaus to analyze the possibility of calculating them, in particular if income and expenditure survey information, or census information, is available.

Step 2. Minimum information required. Average income (preferably per capita, per household). The income per capita median may be used, a figure which is less affected by extremes of information and the number of households.

However, income data does not say much about its distribution, and therefore it is recommended that the Gini coefficient be used. This is calculated on the basis of accumulation by quintiles according to the amount of income received. This indicator is also calculated by statistics and census institutions.

It is useful to know in which areas of municipalities there is a lower concentration of income. However, these data do not say much about the number of poor individuals in the area. In order to overcome this, it is important to analyze poverty indicators. It is recommended that at least an indicator showing the poverty rate should be available.

It is also advisable to search statistics and census institutions for availability of other indicators showing other characteristics of poverty, such as the poverty gap index, which shows the extent of poverty (FGT [1]); the severity of poverty index, which shows how serious the poverty situation is (FGT [2]); the polarization index (P, which shows whether society is showing signs of polarizing into a very poor class and a very rich class).

Poverty levels have been strongly linked to levels of education. It is therefore important to have access to information on education. At least, information about the numbers of literate and illiterate people in the population is required (provided by population censuses).

As an example, the following table, drawn up for the Municipality of the Central Canton in the Province of San José (Costa Rica), shows information about per capita income indicators (Yperc) per household, number of households (Tot Hog – [Total households]); proportion of poor individuals (FGT [0]); severity of poverty (FGT [2], where values close to zero indicate fewer poor areas and values close to one indicate extremely poor areas); polarization (P, where values close to zero indicate a better distribution and values close to one show a marked separation between the poor and the upper classes; that is, the middle class is disappearing). Table 17 also shows the literacy rate in the districts of that municipality.

This information table, as explained above in the "demography" section, can be produced separately and later be linked to the rest of the data. The procedure for incorporating information is exactly the same as before, explained above in detail in the "demography" unit. However, unlike previous cases, we would like to show an additional alternative presentation, in which two indicators and their values are shown jointly.

Table 17.

Microsoft Excel - Base_mapas.xls

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Alfabetismo

	A	B	C	I	M	O	P	R	S
1	PROVINCE	CANTON	DISTRICT	Number Homes	Middle income (income per capita monthly)	Polarization Index	FGT_0	FGT_2	Literacy
2	SAN JOSE	SAN JOSE	CARMEN	1.312	150.811,42	0,378	1,69%	0,12%	3.033
3	SAN JOSE	SAN JOSE	CATEDRAL	4.949	85.868,14	0,398	6,03%	0,65%	13.277
4	SAN JOSE	SAN JOSE	HATILLO	13.951	59.382,45	0,355	11,30%	1,57%	44.644
5	SAN JOSE	SAN JOSE	HOSPITAL	6.317	58.960,15	0,419	16,30%	2,44%	19.679
6	SAN JOSE	SAN JOSE	MATA REDONDA	3.159	152.611,15	0,432	3,97%	0,48%	8.069
7	SAN JOSE	SAN JOSE	MERCED	3.994	72.297,71	0,415	10,15%	1,25%	11.244
8	SAN JOSE	SAN JOSE	PAVAS	19.268	69.852,70	0,514	16,13%	2,38%	39.072
9	SAN JOSE	SAN JOSE	SAN FCO. DE DOS RIOS	6.331	110.021,07	0,371	3,78%	0,41%	18.567
10	SAN JOSE	SAN JOSE	SAN SEBASTIAN	11.351	65.397,68	0,383	10,40%	1,25%	35.012
11	SAN JOSE	SAN JOSE	URUCA	6.857	64.784,42	0,567	22,35%	3,38%	19.810
12	SAN JOSE	SAN JOSE	ZAPOTE	6.223	97.093,39	0,412	4,95%	0,53%	17.735

Four maps are presented next:

Figure 19 shows per capita income per household and number of households. This information has been colored according to level of income (divided into five categories, according to the poverty rate, from 1% to close to 23% of poor people in the district). Furthermore, a circle has been superimposed, the diameter of which indicates the number of households, according to three scales. This approach is similar to that used in the "demography" section, except that it explicitly provides the indicator value as additional information.

Figure 20 shows the rate and severity of poverty. This facilitates locating the areas containing the greatest rates of poor households and analyzing their spatial coincidence with those that suffer from more severe or deeper poverty. It must be kept in mind that it is not necessarily the districts with a larger proportion of poor individuals that show the greatest depth of poverty.

Figure 21 shows per capita income per household and polarization. The high values of P (greater than 0.5) indicate significant levels of class polarization and are a potential source of social conflict (Gradín and Del Río, [2001]).

Fig. 19. Municipality of San Jose: Per capita income and average number of households by district

Fig. 20. Municipality of San Jose: Literacy rate by district

Fig. 21. Municipality of San Jose: Average per capita income and index by district polarization

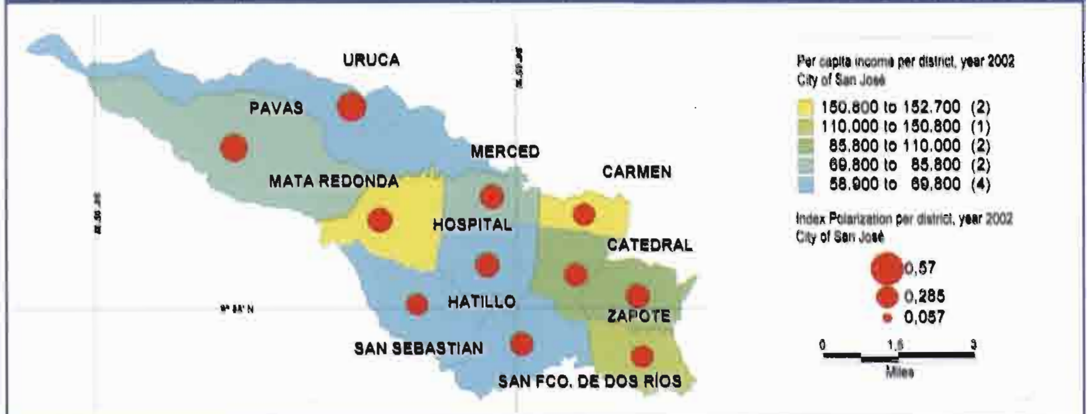


Fig. 22. Municipality of San Jose: Proportion of poor and severity of poverty index by district

Figure 22 shows the literacy rates per district in each municipality. A joint analysis of the four maps shows that the two districts with the greatest rate of poverty are also those with the greatest concentration of severe poverty and lowest literacy rates.

This group of maps offers a detailed overview of the welfare level situation in these districts, and, therefore, their levels of social vulnerability.

Source: Produced by M. Adamson, 2007, based on data from:

- Ramos Esquivel, Carmona Villalobos and Sánchez Matarrita, (2005). Dimensión espacial de la pobreza, desigualdad y polarización en Costa Rica incorporando el principio de la línea de ingreso, período 200-2001. Costa Rica University: School of Economics, Directed Research Seminar.
- Costa Rica National Statistics and Census Institute (INEC).
- "Desinventar" database, produced by the social studies network ("La Red") for the prevention of disasters in Latin America.

A. Composite Indicators of Human Development

Measures taken to improve welfare and human development have become popular in the last few years. For example, the United Nations Development Program (UNDP) has produced a wide range of welfare and human development indicators. Particularly noteworthy is the Human Development Index (HDI), a three-dimensional synoptic measurement of human development:

- **A long and healthy life:** As measured by life expectancy at birth;
- **Education:** As measured by the adult literacy rate and school enrolment; and
- **A decent standard of living:** As measured by GDP per capita (adjusted to purchasing power parity in USD).

This indicator acknowledges that human development does not only depend on monetary income, but also on opportunities, access to education and the opportunity to enjoy a long and healthy life.

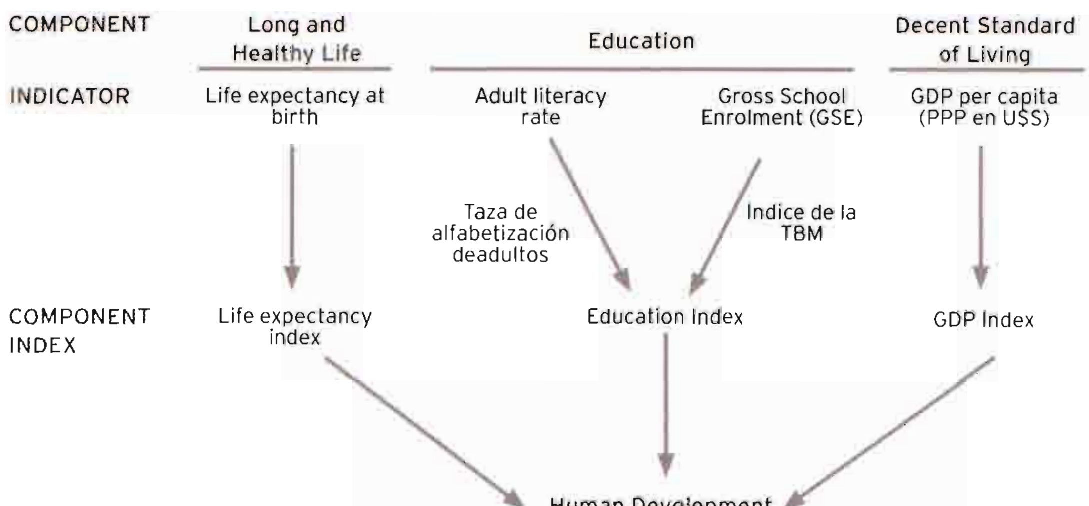


Chart 12.

UNDP offices in different countries and statistics and census institutions have initiated the estimate of this indicator, not only at the country level, but also at the municipal and sub-regional levels. They are also developing other indicator estimates including poverty, gender, etc.

Under this heading, it is advisable simply to check on the availability of HDI and other welfare indicators in the detail required by the municipality, and/or to evaluate the budget available for their calculation. The mechanism for the production of indicators is simple. Variables are chosen according to the measurement aim sought through the use of the indicator (input).

An index is calculated which, following the UNDP method, is just a proportion of two subtractions. In the numerator, the minimum value observed for the variable is subtracted from the variable. The denominator shows the difference between the maximum and minimum values observed for that variable at that geographic scale. That is:

$$\text{Index} = \frac{X_i - \min(X)}{\max(X) - \min(X)} \times 100$$

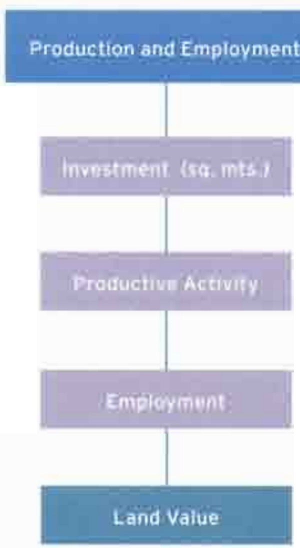
Once this index has been calculated for each of the variables at the desired geographic level, one can simply proceed to calculate the weighted average. For a detailed example, see the Section on Composite Vulnerability Indicators in Stage 5.

Sub-stage 2.4. Production and Employment

Investment: Investment data prepared by each country's Central Bank are aggregate, or, at best, taken by State or Province. Therefore, information regarding annual investment per Censal Unit is usually not available. On the other hand, one of the main components of investment is under the "building" heading. In this sense, municipalities usually grant building permits, whether for housing or commercial and industrial infrastructure, and thus more detailed information in this field is available to them. The number of square meters built is a good indicator of investment and levels of economic activity. Adding this information to the SIGA will allow the municipality to have an idea of the infrastructure's underlying risk, which (in some cases) it could be interesting to monitor as preemptive measures are taken to increase resilience.

In general, engineering and architectural schools and guilds know the estimated cost of construction per square metre in these fields. Using that parameter, the municipality may estimate the rough value of building investment by areas of interest.

Table 18. Sub-stage 24. Production and Employment



The municipality´s productive activities and employment are closely linked to threats, risk and vulnerability. This module has been designed seeking to maximize information that is available to the municipality itself.

Step 1. Review of economic and employment information in databases. Municipalities have a wide range of information on economic activities since it concedes permits, patents, tax collection, etc.

Step 2. Selection of the information to be used and construction of at least the following modules: investment (sq. mts.), levels of economic activity, employment and land value.

Table 19. Production and Employment Variables

Building sq.mts.	Value of Building	Cost/sq.mts.
Sq.mts. dwellings built.		x$ / m^2
Sq.mts. commercial infrastructure built		x$ / m^2
Sq.mts. highways, roads and others built		x$ / m^2

Productive Activities.

It is recommended that at least the following should be included: number of commercial establishments, types of operating licences granted for productive activities and location. This information is significant when it comes to obtaining geographical references for the productive areas by activity, with the aim of designing preventive or mitigating strategies for the impact on productive and working locations, both in relation to economic loss and loss of life. It is suggested that the following variables be included:

Table 20. Employment Variables

Name	Acronym
Economically Active Population per censal unit	EAP
Open Unemployment Rate	OUR
Unemployment Rate	UR

Productive Activity Variables

Number of Business Premises	Premises Density
1. Commercial by type (restaurants and bars, shops, malls).	Number of premises/ sq.mt.
2. Services (banking, health, legal, accounting, security, entertainment and recreation, etc.)	
3. Industry (by type of product, agro food, building).	

Investment

Information for this unit is obtained from the statistics and census institution and is generally available in censal unit detail. It is recommended that at least the "Economically Active Population (EAP)" variable be used. The geographically referenced employment variable is used to identify the centers with the largest concentrations of employed population, and to design preventive and mitigation strategies for the productive locations which warrant them.

Land Value

One of the indicators which best illustrates a municipality's level of economic activity is the price of land. This is a vital parameter in this unit. Municipalities have recently included the design of economic valuation platforms for the price of land, with a great deal of geographic detail and characteristics. These databases could be linked to the SIGA.

It is recommended that the price of the square meter be included, in the local currency as well as in a foreign currency (euros or US dollars, in order to eliminate the effect of internal inflation and to provide an adequate indicator of the real value of the land). The variables recommended are shown in the chart below:

Table 21. Land Value Variables

Local Currency	Foreign Currency
Price/hectare agricultural	Price ($) /hectare agricultural
Price/sq.mt. Urban	Price ($) /sq.mt.
Price/sq.mt. Commercial	Price ($) /sq.mt.

The price of property in different situations may reflect the threats and the level of social vulnerability (poverty, delinquency, etc.). However, when information on threats does not flow adequately, prices may not incorporate that information, which may lead private investors to carry out transactions (buying land, for example) which they might not otherwise have done.

Municipal rates

The dynamics of municipal income collection says a lot about the economic situation of the municipality. For this reason, it is very useful to reference the income geographically, in particular in order to determine the possible impact of a specific event on the financial situation of a municipality, to give an example.

Sub-stage 2.5. Loss due to Disasters

This data unit completes the socio-economic group. Generally speaking, this information is very scattered and has not been compiled or centralized. This is why the chart on page 33 identifies it by means of a red dotted line surrounding it, to indicate that information gaps exist. According to the goal for the next decade established at Kobe, of "reducing economic and social losses", it is suggested that municipalities obtain, in the greatest geographical detail possible–at least–the information shown in the following chart:

Table 22. Losses due to Disasters

People Affected	Infraestructure Affected		Evaluation of economic losses
Number	Number	Percentage	
Number of deaths by type of event (flood, landslide, earthquake, etc.). Number of victims by type of event. Number of injured by type of event.	Number of dwellings affected Number of buildings affected Highways and roads affected in sq. mts. Drinking water pipes affected in sq. mts. Bridges affected in sq. mts. Constructions affected in sq. mts. Hectares affected by type of crop	Percentage affected	Estimated value of losses Estimated value of crops Estimated value of dwellings Estimated value of infrastructure Estimated value roads

The Network (La Red)'s "Desinventar" database facilitates an online review of information, available at http://www.desinventar.org/desinventar.html, which may be used by the municipalities as initial input for updating through the Management Unit. As in the previous case, using value/sq.mt. parameters as a starting point, as well as the percentage of affected square meters to calculate a value which is indicative of the effects of damage, the procedure is simply as shown below:

Initial value of loss =

m^2 affected X percentage of loss X cost/m^2.

This information is processed in the same way as before, and may be reflected on maps. Next, is an example for the Municipality of San José, Costa Rica, which includes a map of the Economically Active Population (EAP), together with the Open Unemployment Rate (OUR); a map showing investment in square meters (hypothetical), a map of average households affected by flood and flood victims (as a percentage in a 30-year series).

Fig. 23. Municipality of San José: EAP and unemployment rate by district

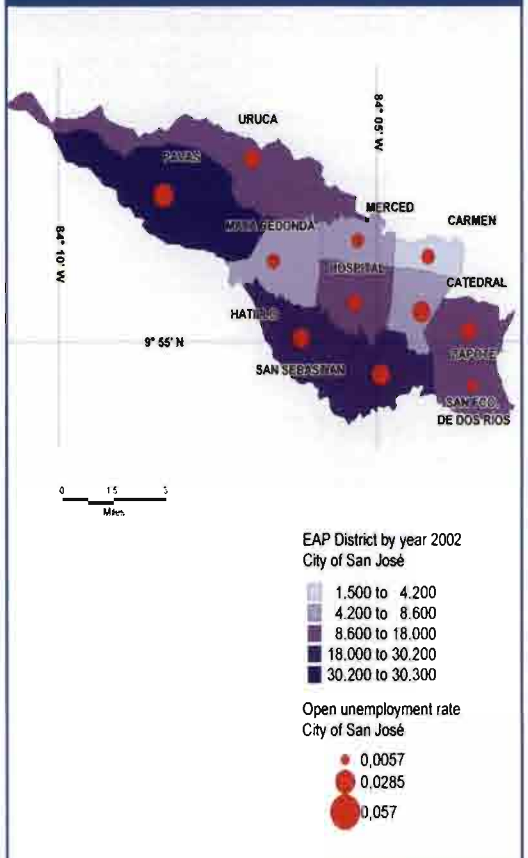


Fig. 24. Average housing affected by flood and total damnified Municipality of San José

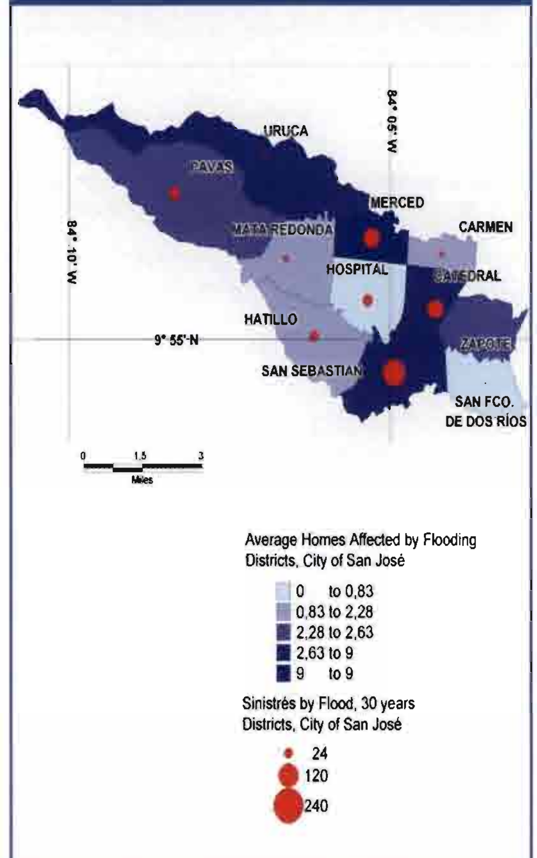
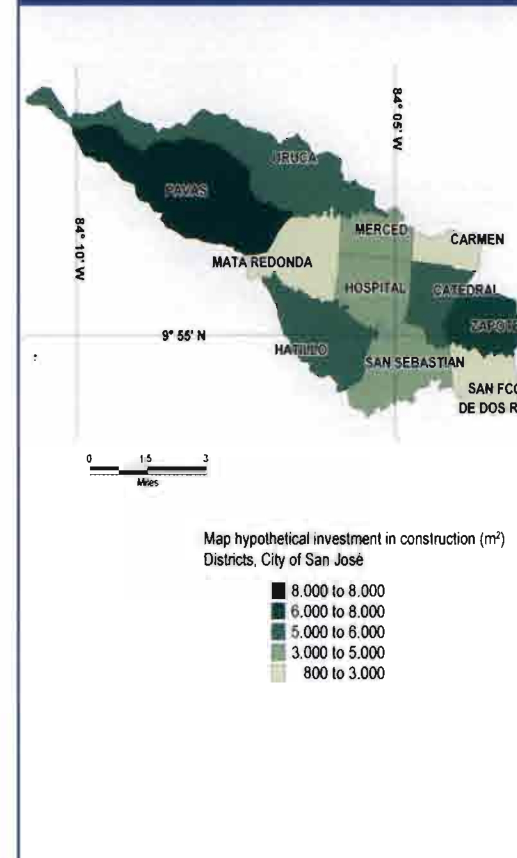


Fig. 25. Municipality of San José: Map Hypothetical Insvestment (m²)



Stage 3. Use of Land

Step 1 – Cartographic Foundation

The aim of this module is to carry out a detailed inventory of the uses of land, of natural resource conservation and/or to identify the alterations which imply a risk to life within the municipality.

At this stage, two groups of land uses can be distinguished: urban and rural.

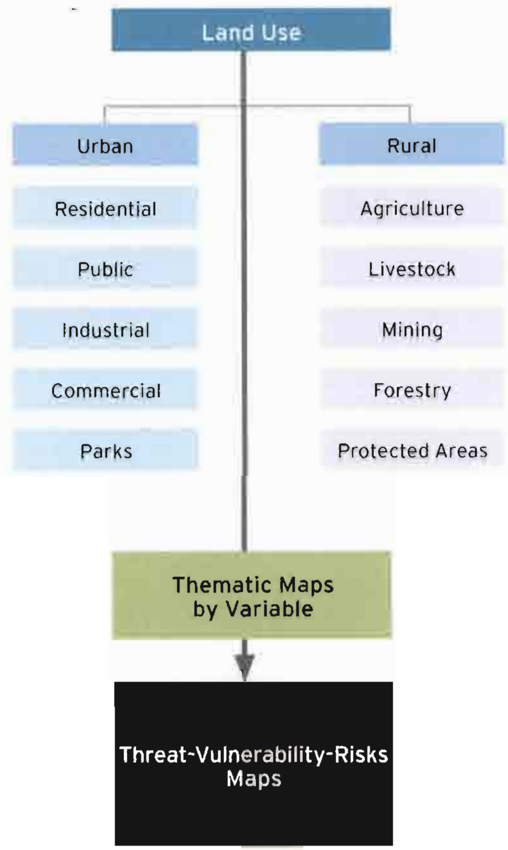
For rural areas, maps are drawn up on a scale of 1/50,000, but if the municipality considers it necessary, it is possible to work on a cadastral scale. For towns and cities, it is recommended that data on a scale of 1/5,000 be obtained and generated.

Step 2- Use of Urban Land

Search for and compilation of information related to the subject, at the level of the municipality, the neighborhood and the city block.

When putting this database together, it is recommended that the Land Registry Bureau's database be used. It would be advisable for information matrices to be structured by subject (housing, commercial buildings, industrial buildings, etc.).

Chart 13. Stage 3. Land Use



Processing of cadastral information, photointerpretation, fieldtrips.

Minimum information required:
sketch of localities according to predominant use, both in urban and in rural areas.

Step 1
Cartographic Foundation
1/50,000 and/or cadastral maps for urban centres.

Step 2
Urban land use

Step 3
Rural land use (agriculture, livestock, mining)

Urban use	Activity Code	Type of Use	Tenure	Value by Activity
Dwellings	8000	Living space	Owned	
		Living space and commercial	Rented	
		Shelters	Lent	
			Uninhabited	
Edificios		State-owned	Public	
		Commercial	Private	
		Services (education, health, transport)		
		Health, recreational		
Industrias	9000	Manufacturers (food, clothing)		
		Tanneries		
		Slaughterhourses		
		Tobacco industry		
		Coffee processing plants		
		Pharmaceutical industry		
		Paint, chemicals		
		Textiles		
		Pork products		
		Service stations		
		Metallurgic industry		
		Cement works		
		Building materials plants		
Comercial		Supermarkets		
		Food and clothing stores		
		Miscellaneous		
		General stores		
		Stalls		
		Public and private transport		
		Distributors		
		Grocery stores		
		Municipal markets		
Green Spaces	10000	Parks		
		Squares		
		Sports fields		

Step 3- Use of rural land

Fig. 23. Using soil
Municipality of Condega, Department of Esteli, Nicaragua

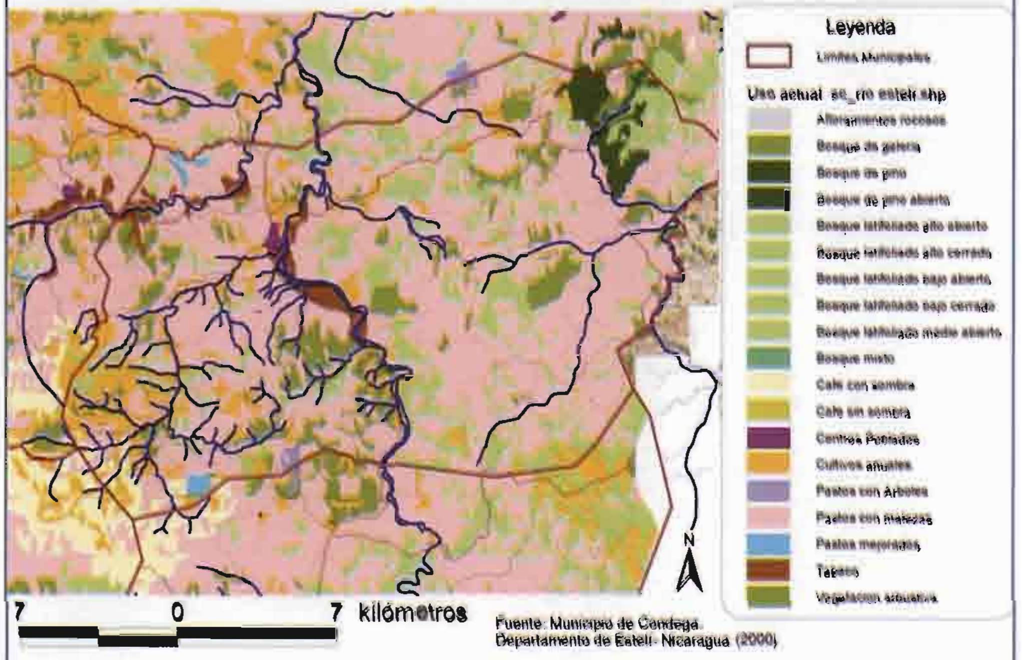


Table 23. Use of Urban Land.

National production data, regarding volume and location, are produced by the Ministry of Agriculture, Livestock and Forestry or similar institutions in each country. It is helpful if that institution provides the relevant maps and information for the municipality. If this is not possible, the municipality itself can generate its own information from its micro-regions, administrative divisions and communities, through the representatives of state institutions or agencies. The information can also be obtained with the support of various Non-Governmental Organizations. Finally, it is possible to carry out field trips to verify, update and/or create the necessary information.

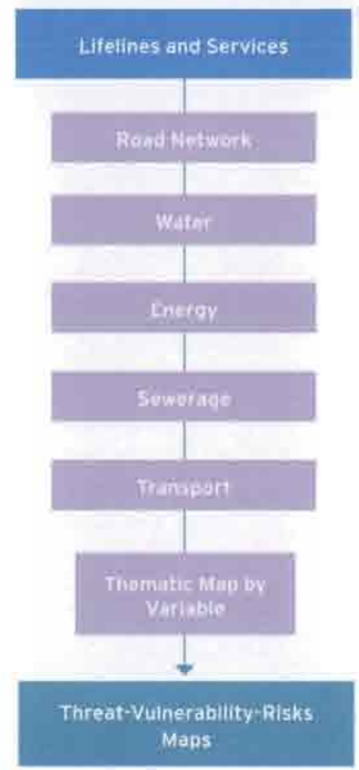
Rural use	Code	Heading	Type	Contamination generated	Effects
Agriculture		Vegetable gardens	Vegetables		
		Cooperatives			
		Traditional crops	Corn Beans		
		Commercial crops	Coffee Sugar cane Tobacco Rice		
Livestock		Extensive	Large livestock		
		Intensive	Small livestock		
Mining		Metals (Iron) Building (sand, clay) Energy Semi precious Others			
Forestry		Coniferous and Latifoliate Forest Mist forest Others			
Protected Areas		Mountain Wetlands Coastal areas			
Energy plants		Hydroelectric dams Sub-stations Geothermal and thermal stations			
Dumps		Municipal Illegal			

Table 24. Use of Rural Land

Stage 4. Lifelines and Basic Services

It is important to include all the information that can be generated at the local level.

Stage 4 - Lifelines and Basic Services



Processing of municipal, cadastral and censal information, and information supplied by State institutions and organizations connected with the municipality. Together with verification and updating via field trips.

Step 1 - Access routes (roads, highways, bridges, etc.)

Step 2 - Water supply and sanitation networks.

Paso 3 - Energy

Paso 4 - Health (hospitals, outpatient clinics, health centres, health posts)

Step 5 - Education

Step 6 - Transport

Figure 24.

Setp 1

Access Routes.

There is a nomenclature which refers to categories of roads: hard surface highways, secondary highways, roads passable in all kinds of weather, unimproved roads, lanes, narrow paths.

Order of importance of the roads : Types of road in the municipality.

Condition: State of road's upkeep (permanently updated).

Surface category: Material used in its construction.

Evacuation capacity: Feasibility of using the road as an evacuation route.

Order of Importance	Condition	Surface Category	Evacuation Capacity
Main highway Secondary roads Passable in all kinds of weather Unimproved roads Lanes Narrow paths	In good shape, in poor shape.	Asphalt Cobbles Ballast Macadam	High, medium and low.
Bridges		Concrete, wood, mix, metal, etc.	

Table 24.

Step 2

Water supply network and sanitation

Services: Type of water supply network and sanitation.

System: Description of the system used to provide the service.

Materials: Type of material used to build the supply system.

Type of service: Continuity of service.

Service quality: Quality of the service and quality of the water.

Services	System	Type of material	Type of service	Quality of service
Drinking water Sewer System	Wells, pipes, networks.	PVC, metal, concrete, etc.	Continuous, sheduled, occasional	Good, fair, bad.
Rain water	Pipes, canals	PVC, metal, concrete, etc.		
Septic tanks or troughs	Individual or collective	Concrete, covered, lined, uncovered.	Permanent	
Latrines	Individual or collective	Wood, metal, concrete, blocks, fiberglass, plastic.	Permanent	
Oxidation tanks	Collective	Concrete, covered, lined, uncovered		

Table 25.

Step 3

Electric Power

Service: Type of power grid.

System: Description of the system used to provide the service.

Materials: Type of materials used to build the power grid.

Maintenance: Service maintenance schedule.

Type of service: Continuity of electrical service.

Location of system: Threat - hazard - due to proximity to the grid.

Services	System	Type of Material	Type of Maintenance	Type of Services	System location
Household electric power lines	Local, municipal networks	Cables, pylons, wooden, concrete or metal	Permanent, temporary, nonexistent	Continuous, shceduled, occasional	High hazard Low hazard
High voltage lines	Local, municipal networks				
High and low voltage stations	Local, municipal networks	Transformers, cables and infrastructure			

Table 26.

Step 4

Health (hospitals, outpatient clinics, health centers, health posts)

Service class: Existing health services.

Health care capacity: Type of health care provided by the health centre (care level).

Accountable to: Organization responsible for maintaining the health service.

Human resources: Human resources available at health centre.

Infrastructure: Physical resources available to the health service.

Type of Service	Care capacity	Accountable to	Human resources	Physical resources
Hospitals	Provide care at the 3 levels	Public, mixed or private	Doctors, male and female nurses, nursing auxiliaries, administrators, cleaning personnel, maintenance.	Collective wards, private wards, isolation wards, intensive care wards, operating theatres, laboratories, ambulances, lighting, drinking water, sewage, offices, garbage disposal, crematoria, sanitary facilities, access
Outpatient clinics	Primary and secondary			
Health centers				
Health posts			Doctors, nurses, nursing auxiliaries	Outpatient areas, offices, sanitary facilities, access
Base houses	Primary			

Table 27.

Step 5
Education

Service class: Existing educational services.

Student population: Number of students.

Accountable to: Organization responsible for maintaining the educational service.

Building type: Materials used in the buildings.

Human resources: Human resources available at educational centre.

Infrastructure: Physical resources available to the educational service.

Important note: This information facilitates the preparation of emergency plans.

Type of Service	Student Population	Accountable to	Type of Building	Human resources	Physical resources
Pre-school	Number of children, adolescents and young people	Public, mixed or private	Adobe, wood, concrete, tiles, zinc, floor (mud, concrete, ceramic, etc.)	Teachers, professors, directors, assistant directors, administrators, cleaning personnel, maintenance	Number of classrooms, courts, gyms, laboratories, chapels, coffee shops, storerooms, lighting, drinking water, sewage, garbage disposal, access
Primary					
Secondary					
Technical					
University					

Table 28.

Step 6
Transport

Transport system Local and long distance transport.
Frequency: Timetables.
Accountable to: Organization in charge of providing the service.
Coverage Quality of service.
Physical resources: Available infrastructure.

Transport System	Frequency	Accountable to	Coverage	Physical resources
Defined Routes	Fixed shedules	Public, mixed or private	Efficient, fair, poor	
Specified stops				Roofed, open air, lit, unlit, with signs, without signs, maintenance, cleaning
Terminus				Roofed, drinking water, sanitary facilities, sewage, lighting, sufficient space, parking, offices and commercial areas, maintenance, cleaning, access.

Table 29.

Stage 5
Processing Stage

A-Production of Indicators

For the Geophysical System´s Characteristics, five variables considered fundamental in the definition of the geophysical system are used: hydric network, elevation measurements, basins, geology, geo-morphology.

	Indicators. Indicators code by attribute		Cartographic Product	
PROCESSING STAGE	•	Geophysical indicators code	•	Cross-referencing between thematic geophysical maps
	•	Threat indicators code	•	Production of natural threat map ¿hydrometeorological, volcanic, earthquakes?
	•	Cross-referencing between thematic maps and socio-economic database	•	Cross-referencing between socio-economic thematic maps
	•	Vulnerability indicators code	•	Production of vulnerability map
	•	Land use code	•	Land use map
	•	Lifelines and services code	•	Lifelines and services map
	Environmental risk indicators code		Environmental risk map production	

Table 30.

Hydric Network Design

Id_red (network id): Topological code.

Hierarchical classification: Stralher's hierarchical classification system.

Cod_Jer (Hierarchy code): Number assigned to each order.

Water volume: Characteristics of water volume (permanent or intermittent).

Cod_cau (water volume code): Number assigned according to volume size.

Attributes: Description according to performance in the face of heavy rainfall threat.

Network_ID	Hierarchical classification	Hierarchy code	Water volume	Water volume code11	Attributes	Code_Attrib_network_
3000	1st line	1	intermittent	22	torrential	113
3001	2nd line	2	permanent	32	slope	221
3002	3rd line	3	permanent		plains	325

Table 31.

Cod_attrib (Attribute code): Number assigned.

Topographical_ID	Spot height (meters)	Altimetric level	Attributes	Height_code
14	100	100-500	low	1
23	500	501-1000	medium	2
35	1000	1001-2000	high	3
396	2000	2001-3000	very high	4

Table 32.

Municipal limits (universal coverage)

Topographical Attributes

Topographical ID: Topological Identifier.

Spot Height (in meters): Height Levels, obtained from terrain.

Altimetric level: A group of spot height data (contours are grouped by height category, for example: contours between 0 and 100; contours between 100 and 600; contours 600 and above, etc.).

Attributes: Relevant characteristic of attribute (low area, medium area and high area; this is determined by technicians).

Cod_altitud (Altitude code): Classified from higher to lower.

River basin delimitation

Id_cuenca (Basin Identification): Topological code.

Name: Actual nomenclature (actual name of the rivers or mountain streams which compose the basin) or a name established for each basin whose limits have been determined.

Cod_cuenca (Basin code): A code number to identify the basin.

Basin_ID	Name	Basin_code
100	basin A1	1
200	basin A2	2
300	basin A3	3

Table 33.

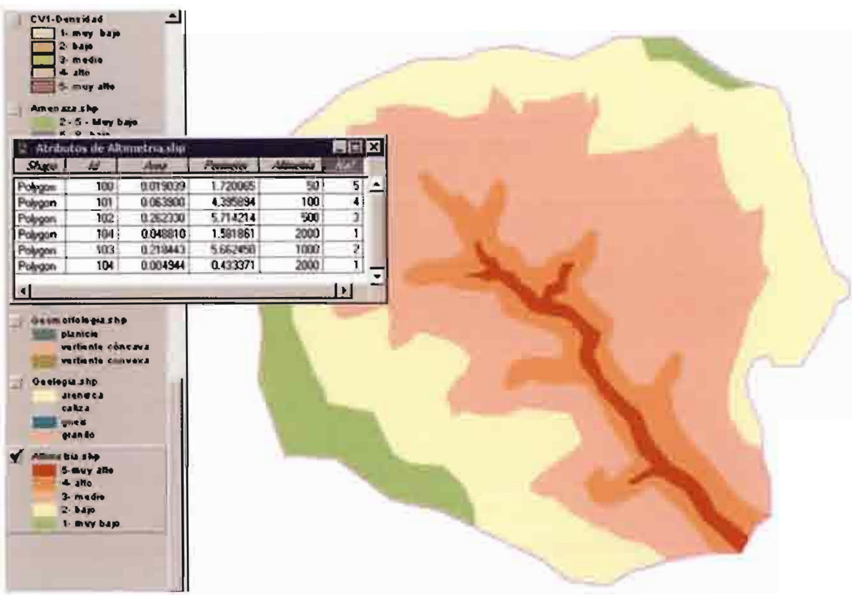


Figure 25.

Geological attributes

Id_geol (Geological Identification): Topological code (the number of the form type, created by means of a polygon).

Formations: Actual nomenclature (name) used for each formation.

Cod_geol (Geological Code): Code number assigned to each formation.

Rock type: Names of rocks.

Cod_rocas (Rock Code): Code number assigned according to hardness of rock.

Tectonic: Characteristics and properties of the rock.

Cod_tect (Tectonic Code): Code number assigned according to properties.

Attributes: Stability, meteorization, permeability, others.

Cod_atrib (Attribute Code): Code number assigned according to stability.

Geol_ID	Formations	Geol code	Rock type	Rock code	Tectonic	Tectonic code	Attribute	Geol_attrib_ code
1000	Precambrian	1	Granite	10	Inactive fault	100	Stable	1000
1001	Mesozoic	2	Limestone	25	Inactive fault	250	Stable	2500
1002	Cenozoic	3	Riolite	38	Active fault	381	Unstable	3811

Table 34.

Geo-morph_ID	Major geomorph	GM code	Minor geomorph	gm code	Attribute	Geom_ attrib_code
2000	Plain	1	River plain	11	Flood-prone	111
2001	Slope	2	Alluvial cone	23	Landslide-prone	233
2002	Montane	3	Glacis	35	Avalanche-prone	355

Table 35.

Geo-morphological Attributes

Id_geom (Geo-morphological Identification): Topological code.

Geomorph: Actual nomenclature (name) of each geomorph (plains, slopes, mountains).

Cod_GM (Geo-morphological Code): Code number assigned to each geomorph.

Minor geomorphs: Properties of geomorphs.

Cod_gm (Geo-morphological type Code): Code number assigned according to type of geomorph.

Attributes: In the face of a threat.

Cod_atrib (Attribute Code): Assigned numbers.

Preparation of Codes for Geophysical Indicators

In order to create the indicator codes, attributes are crossed through the intersection of coverages, forming a mosaic.

1- This mosaic, at the graphic level, is originated when coverages are superimposed and intercepted, resulting in a subdivision of polygons.

2- Tables are crossed automatically (DBase, Excel, SIG operation) in a matrix (intersecting rows and columns). As a result of the operation (multiplication) each matrix level obtains a composite code:

How is this result read? Each basin extends the length of four attributes. In the example, only one basin (Basin 2) will be used, intersecting the topography and geology attributes.

IMPORTANT: Each cell in the table has a value which is the product of the intersection. When the value is zero (0) it means that the geological formation is not present at that level.

As variables are added, the same methodology is applied.
From the intersection of the five variables for the basin, the following table of results is obtained, together with the corresponding map:

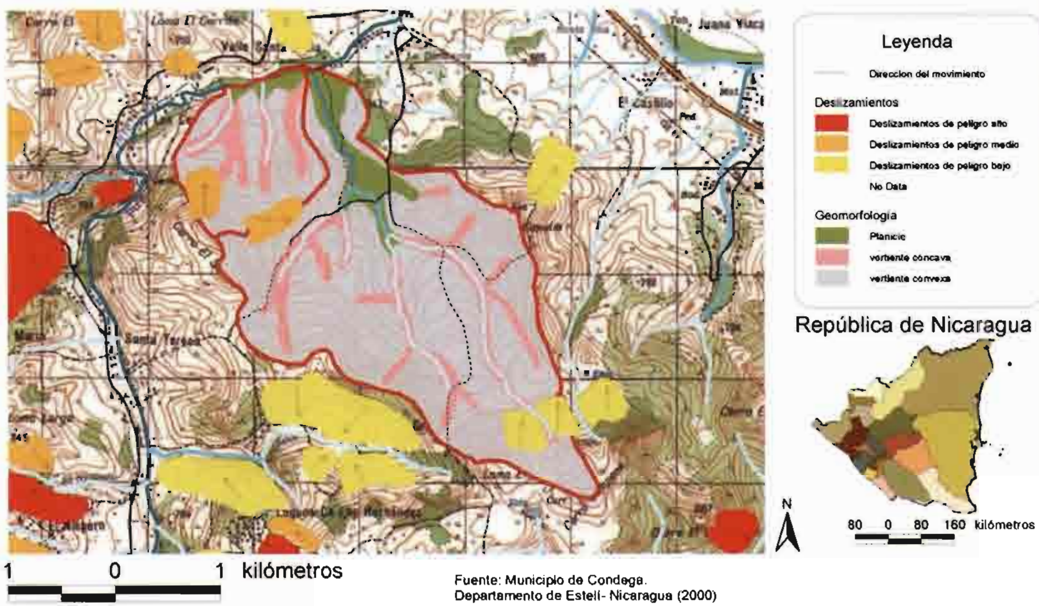
B-Preparation of Threat Maps

A possible first way of going about this is to combine the table obtained previously (geophysical system) with the occurrence probability of the threat(s) –that is, the risk estimate– to which the municipality is exposed. A new table will thus be generated. It must be considered that:

- As the estimate of the occurrence probability of each event is a specific datum, it could be determined by the Management Unit, since it depends on the location of the municipality and on existing records, which are influenced by the specific characteristics of the type of event.
- The estimate of a probability model can be a somewhat laborious task, and it may be possible that there are no previous estimates available. In such a case, the management unit can proceed by assigning a numerical code to each category, according to existing perceptions of occurrence probability (groups of specialists may be consulted for each type of event, for example, in focus group workshops).

The second alternative consists of the estimate of the occurrence probability of the threat (of the event). That is, this probability provides a risk estimate, which can be combined with information about vulnerabilities, and in many cases be complemented by historical information. An example of this will be given below, in the section on the production of composite indicators.

Fig. 26. Landslide Threats in the Municipality of Condega, Department of Estelí, Nicaragua



Fuente: Municipio de Condega.
Departamento de Estelí- Nicaragua (2000)

C- Attributes of the Socio-Economic System

Use is made of the variables mentioned in this unit that it has been possible to obtain. The minimum variables recommended in this manual are required, plus any additional variables which may be of interest to the municipality (units on demography, welfare and development, productive activity and losses). The sources of information, as pointed out before, are varied (from population and housing censuses to income and expenditure surveys; university research centers and institutions, graduation papers, etc. It is recommended that the smallest territorial unit or censal area available be used).

> IMPORTANT: In order to determine the attribute it is recommended (as an approximation) that the average value of the corresponding variable in the municipality be used as a reference and, on that basics, that a category be established and codified before.

As an example, for a few of the variables in these units:

It is important to include poverty variables, and employment, which in this case are excluded so as not to lengthen the example. Section H shows how to include these variables in the development of quantitative indicators.

Population

Area_ID	Population	Area (sq.mts.)	Density (p/s)	Attribute	Dens_code
1562	156	10.000	156/10.000	Medium	2
2398	26	5.000	26/5.000	High	3
498	800	100.000	800/100.000	Low	1

Sex

Area_ID	Population	Male	Female	Male index	Attribute	Sex_code
1562	156	80	76	80/76	Medium	2
2398	26	6	20	6/20	High	3
498	800	500	300	500/300	Low	1

Age

Area_ID	Population	0-14	15-64	65 and over	Attribute children	Child. code	Attribute older adults	OA_code
1562	156	32	68	56	Medium	2	High	3
2398	26	5	12	11	Low	1	Medium	2
498	800	220	520	60	High	3	Low	1

Health Coverage

Id_zona	Population	No coverage	With coverage	No coverage index	Attribute	Health_code
1562	156	10	146	10/146	Low	1
2398	26	16	10	16/10	Medium	2
498	800	600	200	600/200	High	3

Housing Quality

Area_ID	Dwellings	Heavy materials	Light materials	Dwell. quality index	Attribute	Dwell_code
1562	58	50	8	8/50	Low	1
2398	8	2	6	6/2	High	3
498	142	40	102	102/40	High	3

D- Production of Vulnerability Indicator Codes

The SIGA provides a wide variety of possibilities with regard to the preparation of indicators to quantify and monitor progress in vulnerability reduction and the increase of local resilience, as recommended in the Hyogo Plan of Action.

Two alternatives are shown below for the production of vulnerability indicators. In both cases, indicators are obtained by seeking a quantification of the dimensions of the vulnerability concept.

Quantitative vulnerability indicator: For each variable which approximates a specific vulnerability dimension, it is necessary to find a measurable magnitude to quantify it. The production of a quantitative vulnerability indicator may be a laborious task from the conceptual and measurement point of view. Because of this, this case is presented as a second example.

Qualitative vulnerability scale: Unlike the previous alternative, in this case it is only necessary to establish a numerical scale for the variables in each dimension (for example: 3-high, 2-medium, 1-low) and then add up the values, as in previous examples. The precaution of keeping to a logical order in the distribution of values must be taken, making sure that the higher values, or the lower ones, always correspond to a situation considered either positive or negative.

No pre-determined number of variables is needed to produce the qualitative or quantitative vulnerability indices. It is recommended that a sufficient but manageable number be used. Variables must be associated with the effects of the threat/s and to the socio-economic dimensions that they affect.

As a result, a qualitative analytical code is obtained as well as an aggregate vulnerability code. An example of a social vulnerability case is shown below:

Area_ID	Dens_Code	Sex_code	Child_code	OA_code	Health_ code	Dwell_ code	Analytical vuln_code	Aggregate vuln_code	Level
1562	2	2	2	3	1	1	222311	11	Low
2398	3	1	1	2	2	3	311223	12	Medium
498	1	3	3	1	3	3	133133	14	High

Table 36.

The analytical vulnerability code enables the identification of variables which make the greatest contribution to vulnerability. The aggregate code gives a more general view. In the latter case, when the analysis is carried out, **it must be kept in mind that identical final figures may be reflecting very different situations concerning the effect of the participating variables.**

The Management Unit can use both indices, according to the **SIGA**'s specific aims and to the criteria regarding intervention in the socio-economic variables, for example by means of social investment or other projects which seek to increase resilience.

In short, the general procedure to be followed is made up of the following steps:

- Selection of dimensions included in vulnerability (social, physical, cultural, etc.).
- Selection of variables related to such dimensions (for example: a high population of children and older adults implies greater social vulnerability). Not necessarily so if their income is high and they are located in low threat areas.
- Selection of indeces to quantify the variables chosen (for example: percentage of children and older adults with respect to the total population).
- Creation of classes for each variable, according to category (low, medium and high) and assignment of a number to each class.

  For example: 1-low, 2-medium, 3-high.
- Production of the analytical and/or aggregate vulnerability index.
- Vulnerability map.

E- Attributes of Land Use

The categories suggested for the typification of the use of land in urban areas are: residential, public, industrial, commercial, green areas, unused and unspecified use.

In rural areas, the following categories are used: livestock, agriculture, mixed, forestry, industrial, mining, protected areas, an 'unused' category and an 'unspecified use' category.

In both cases, the typology may be broadened according to the specific characteristics of the municipality.

The binary code system can be used to assign the codes: presence (1) - absence (0).

This will generate a table describing the use of land, similar to the one shown below:

Table 37.

Land_ID	Urban							Urban_code	Rural									Rural_code
	Res.	Publ	Ind	Com	ev	N/u	N		agr	liv	mix	for	ind	min	PA	N/u	N	
5001	1	0	1	1	0	0	0	1011000	0	0	0	0	0	0	0	0	0	000000000
5002	1	1	1	1	0	0	0	1111000	0	0	0	0	0	0	0	0	0	000000000
2034	1	0	1	0	1	0	0	1010100	1	1	1	0	1	0	0	0	0	111010000
257	1	0	0	0	0	0	0	1000000	0	0	0	0	0	0	1	0	0	000000100

F- Attributes of Lifelines and Services

Lifelines to consider could be classified as: road network, water, electricity and sewer system. The names of the types within each category may vary according to the country or region. In all cases, the condition of the line in question is included.

Tables are produced as follows:

Road Network

Road network_ID	Type	Road_code	Condition	
100	National highway	10	Good	3
125	Departmental highway	12	Poor	1
136	Road		Good	3
25	Path		Fair	2
101	Road		Poor	1

Water

Water_ID	Access	Access_code	Quality of service	
200	Pipes	20	Poor	1
201	Well	30	Good	3

Electricity

Electr_ID	Type	Light_code	Condition	
300	Electric	301	Fair	2
301	Lamp	526	Good	3

Sewer System

Sanitation_ID	Type	Sanit_code	Condition	
100	Network	357	Good	3
101	Tank	159	Fair	2

On the subject of services, the following are taken into account in the SIGA: health, education and transport. In this case, the typology may vary as well. Infrastructure quality is considered for each case:

Serv_ID	Type		Infrastructure	
25	Health	Hospital,	Good	3
		Outpatient clinic,	Fair	2
		Community clinic	Poor	1
1980	Education	Primary	Good	3
		Secondary	Fair	2
		Tertiary	Poor	1
35847	Transport	passengers		
		cargo		
		Hazardous waste		

Table 38.

ID	Sub-basin	Geophysical_code	Flood likelihood		Area_ID	Analytical vuln_code			Potential risk	Use_code	Lifelines and services		
											c	s	a
1001	2	211000111113	3	High	1562	222311	1	Low	High-low	Agriculture	0	0	0
503	2	222500233221	2	Medium	2398	311223	1	Low	Medium-low	Livestock	1	0	0
3519	2	2338111000221	1	Low	498	133133	3	High	Low-high	Residential	1	1	1

Table 39.

The information provided by the lifelines and services sub-system is of use to the management unit, since it makes it possible to become familiar with the infrastructure. The latter can be counted upon in the case of a disaster, as well as the level of damage which this infrastructure might suffer in such an event.

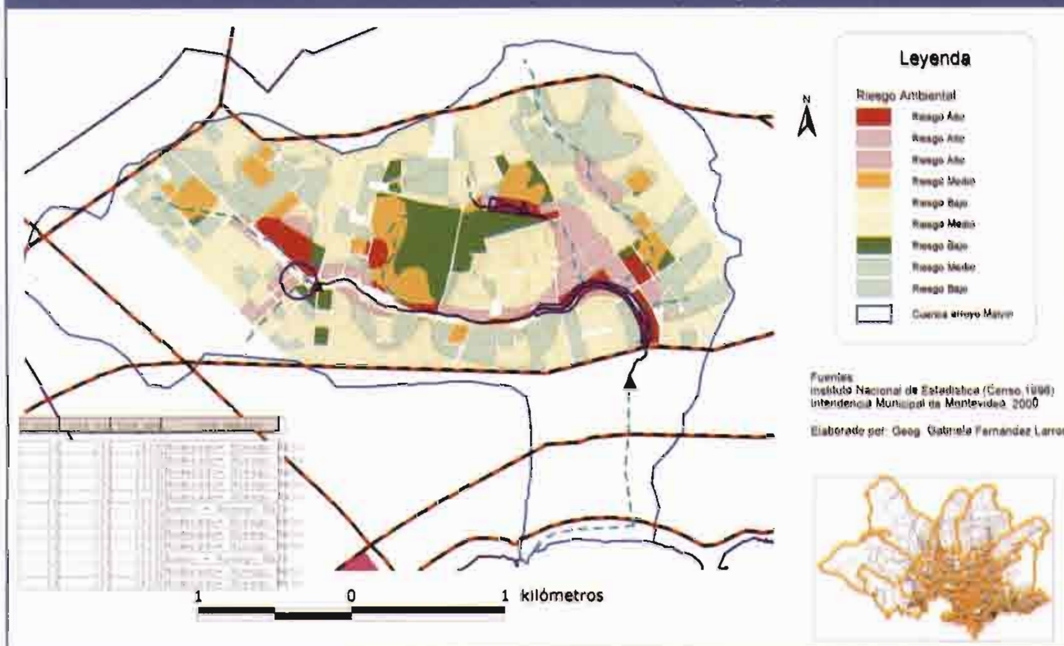
G- Preparation of Environmental Risk Maps

With the availability of information about threats, vulnerability, use of land and lifelines and services, it is possible to produce an **environmental risk map**.

This map is a summary of the environmental situation (including economic, social and other aspects) of the municipality's territory in the face of a particular threat.

The final summary map, or environmental risk map, which the Management Unit will obtain, will be similar to the map shown below:

Fig. 27. Environmental Risk Map
Malvín stream basin, Montevideo, Uruguay



Depending on the characteristics of the municipality and on the type of threat/s to be faced, the management unit will classify the environmental risk areas that are best suited to its needs.

In some cases it will be advisable to work with a restricted classification (for example: high, medium, low or zero risk); on the other hand, in other cases it will be advisable to use a wider range of categories, which can even be numbered (for example: 0 – zero risk; 10 – very high risk).

It is by using this summary map that the municipal authorities can complement their information and contrast it with their action and budget priorities. This is done for the purpose of facilitating the administrative and political decision-taking process, in relation to risk management and increased resilience.

H- Quantitative Composite Vulnerability Indices (CVI)

It may happen that the municipality has not been able to complete all of the SIGA units. If, for example, the geophysical module has not incorporated all of the necessary details, the Management Unit can resort to historical information and records, and use them to prepare indicators, which, although they do not necessarily contain the required detail, do provide information for the decision-making process. This indicator will provide the prevailing vulnerability on the date of the available information. All that is required for this is historical information and tools such as a simple electronic spreadsheet.

As an example of this situation, which may arise in the initial stages of the SIGA's design and preparation, and also to illustrate other ways of calculating vulnerability indicators, several approaches are developed below for the production of quantitative vulnerability and risk indicators.

Step 1. Definition of a temporal scale and an analysis indicator mode

- **Define the scale or temporal coverage which is desired for the use of data and review the availability of information.** In this case it is important to define the time interval to be employed (the example is produced using flood victim reports over a 30-year period: 1970-2000. Data obtained from Desinventar, The Network). In this example, the indicator is produced by taking the average number of victims per flood.
- **Define the type or mode of indicator.** It is recommended that the UNDP method employed in producing the indicator be followed. This uses maximum and minimum numbers, and allows comparisons within the same geographic or censal unit.

In this example, a vulnerability indicator of victim per flood (VIVF) is sought. Therefore, the average number of victims per flood in area i can be calculated, which, for example, can be defined as the number of victims divided by the total number of flood reports during the period, (Xi/Total floods in the municipality X 100).

Step 2. Calculating the vulnerability index by characteristics

- **Identify the minimum and maximum of the variable within the municipality.** The next step is to find the minimum and maximum values for the indicator (in this example, average victims per flood, per geographical unit). This makes it possible to carry out comparisons among the different areas. In this example, a comparison is made among the districts that constitute the municipality of San José, Costa Rica.[1]

G2 ▾ fx =(F2-F14)/(F13-F14)

	A	B	C	AM	AQ	AR	AS
1	PROVINCE	CANTON	DISTRICT	Number of floods	Sinistrés floods	Sinistrés average floods	Floods Victims Vulnerability Index
2	SAN JOSÉ	SAN JOSÉ	EL CARMEN	11	12	1,1	2%
3	SAN JOSÉ	SAN JOSÉ	CATEDRAL	21	139	6,6	15%
4	SAN JOSÉ	SAN JOSÉ	HATILLO	11	47	4,3	9%
5	SAN JOSÉ	SAN JOSÉ	HOSPITAL	12	49	4,1	9%
6	SAN JOSÉ	SAN JOSÉ	MATA REDONDA	6	18	3,0	7%
7	SAN JOSÉ	SAN JOSÉ	LA MERCED	3	135	45,0	100%
8	SAN JOSÉ	SAN JOSÉ	PAVAS	6	74	12,3	27%
9	SAN JOSÉ	SAN JOSÉ	SAN FCO. DE DOS RÍOS	1	0	0,0	0%
10	SAN JOSÉ	SAN JOSÉ	SAN SEBASTIAN	30	237	7,9	18%
11	SAN JOSÉ	SAN JOSÉ	LA URUCA	11	10	0,9	2%
12	SAN JOSÉ	SAN JOSÉ	ZAPOTE	14	2	0,1	0%
13					Max	45,0	
14					Min	0,0	

Table 40.

Source: M. Adamson, 2007.

- **Prepare the indicator estimate equation.** Once the maximum and the minimum have been found, a formula is established for the calculation of the victims per flood index. This may simply be done on a spreadsheet, as shown in the figure above. The equation is simple: subtract the minimum value found per geographical unit from the indicator. Divide the result by the difference between the maximum and the minimum values. The quantitative vulnerability indicator can be given as a percentage.

$$IDVI = \frac{DPI_i - Min\{DPI_i, \ldots, DPI_n\}}{Max\{DPI_i, \ldots, DPI_n\} - Min\{DPI_i, \ldots, DPI_n\}}$$

The more vulnerable areas will show higher values, 100% being the maximum rating, which indicates that that specific area is the most likely to have flood victims. Therefore, the indicator is comparable and relative to the interior of the municipality and not outside it. Please note that the indicator contains two dimensions: a social dimension, as in this example, broadly summarized by the average number of victims, and the threat situations which have actually occurred, that is, the number of events or floods which have taken place.

Step 3. Produce other specific vulnerability indicators.

This type of calculation may be designed equally simply, for indicators such as a death by flood vulnerability index, or for a housing affected by floods vulnerability index, etc., according to the needs of the municipality.

The vulnerability risk map shows the VIVF for the Municipality of San José, together with other composite vulnerability indicators, which are explained in the following paragraphs. for the sake of simplicity. Historical information was used in these examples. Similarly, it is possible to determine vulnerability due to flooding caused by an increase in the volume of a watercourse, in terms of a specific number of meters above the average level. In this case, it is possible to calculate the

[1] It must be kept in mind that these are examples. In this case, as an illustration, the "Desinventar" database has been used, which contains data on the effects on housing. However, as the municipality's Management Unit improves its statistics, in coordination with other institutions, the data will tend to become more precise.

number of potential victims and produce an index to serve as a vulnerability forecast based on the contour lines described in the geophysical unit and on information about the population. The mechanism is equally simple; it only requires maintaining systematization.

I- Designing compound vulnerability indicators (CVI)

It is possible to produce a quantitative vulnerability index of a social group with respect to a threat. As pointed out above, vulnerability is multi-dimensional. Therefore, a compound index is produced, which groups various elements considered relevant to a specific vulnerability.

As a manner of illustration, some examples of compound vulnerability indicators by event are provided in the following step. In these cases, work has been carried out along the lines of the conceptual framework produced in Kobe, which highlighted the importance of prevention and mitigation, and of monitoring the cycle of poverty-disaster-degradation of natural resources.

Step 1.
Define the number of variables to be included in your indicator.

The variables that can best quantify and explain the chosen vulnerability must be identified, according to the characteristics of the threat and the information available.

An easily understood way of doing this is by designing a composite indicator in the HDI style (see the section on welfare and human development compound indicators in the appendix), combining various dimensions: an indicator for social vulnerability, one for economic vulnerability and a relative indicator for threat-associated risk. In these cases, threat, as well as social and economic factors are brought together to reflect vulnerability effectively as a result of these interactions.

Next, select the variables to be used in calculating these dimensions and prepare a specific vulnerability indicator for each one, just as was done in the case of the VIVF example.

An example is given below of the preparation of a composite vulnerability to flood index (CVFI). This will be presented in two different ways:

A. The first shows the estimated vulnerability as the weighted average of: a) existing poverty per district (Average Poverty Index [FGT (0)]; b) vulnerability of victims per flood (VIVF); and c) housing affected by floods vulnerability (HFVI).

B. The second, in an analogous manner, considers: a) poverty percentage; b) vulnerability of victims per flood; and c) vulnerability index of economic losses by flood (VIELF).

Step 2.
Define the equation and weighting factors.

As in the previous case, the equation can easily be presented on an electronic spreadsheet. What equation can be used? In these cases, simple equations are recommended: weighted averages of indicators, and the same weighting factor in the exponents. Thus, the equation will simply be a weighted average, as in the examples given above.

In our example, these indicators consist of three variables. This is why it is divided by three, and the value given to the exponent is 1/3; as shown in the equation in Table 41. Among the variables used is the poverty average, which is clearly affected by income. It is to be expected that the lower the income, the more likely it is that housing will be located in cheaper and more marginal areas and will therefore be more exposed to threat from flooding. The type of area is also relevant. Areas with a history of flooding increase the vulnerability of housing. This history, in the present case, is quantified by means of the victim vulnerability per flood index (VIVF).

To obtain an even more detailed vulnerability indicator, more variables can be used, as long as—as previously stated—systematization is maintained in their preparation (to see further details on the production of such indicators, Sudhir Anand y Amartya Sen, "Concepts of Human Development and Poverty. A Multidimensional Perspective") may be consulted.

Another important element is the vulnerability of the physical structures of houses. For this reason, the index showing housing destroyed by flooding (HDFI) is included, to provide an approximation of that vulnerability. The way the exponents are included gives equal weight to the different components of the joint indicator.

I2 f_x =POTENCIA((1/3)*(POTENCIA(E2*100;3)+POTENCIA(F2*100;3)+POTENCIA(G2*100;3));(1/3))

	B	C	D	E	F	G	H	I	J
1	PROVINCE	CANTON	DISTRICT	FGT_0%	IVDI	IVVI	IVPI	IVCI (a)	IVCI (b)
2	SAN JOSÉ	SAN JOSÉ	CARMEN	1,69%	2%	13%	8%	9,03120	1,62305
3	SAN JOSÉ	SAN JOSÉ	CATEDRAL	6,03%	15%	38%	94%	26,91089	65,26984
4	SAN JOSÉ	SAN JOSÉ	HATILLO	11,30%	9%	15%	56%	12,27372	38,98764
5	SAN JOSÉ	SAN JOSÉ	HOSPITAL	16,30%	9%	5%	100%	12,00058	69,45287
6	SAN JOSÉ	SAN JOSÉ	MATA REDONDA	3,97%	7%	9%	56%	7,23164	38,85810
7	SAN JOSÉ	SAN JOSÉ	MERCED	10,15%	100%	100%	19%	87,37327	69,51834
8	SAN JOSÉ	SAN JOSÉ	PAVAS	16,13%	27%	26%	19%	23,99685	21,71974
9	SAN JOSÉ	SAN JOSÉ	SAN FCO. DOS RIOS	3,78%	0%	0%	18%	2,62091	13,20835
10	SAN JOSÉ	SAN JOSÉ	SAN SEBASTIAN	10,40%	18%	31%	19%	23,05173	16,63741
11	SAN JOSÉ	SAN JOSÉ	URUCA	22,35%	2%	29%	56%	22,80091	39,68475
12	SAN JOSÉ	SAN JOSÉ	ZAPOTE	4,95%	0%	25%	100%	17,37877	69,33893

$$IVCI_a = \left[\frac{1}{3}\left((FGT\_0)^{\alpha} + (IVDI)^{\alpha} + (IVVI)^{\alpha}\right)\right]^{\frac{1}{\alpha}}$$

$$IVCI_b = \left[\frac{1}{3}\left((FGT\_0)^{\alpha} + (IVDI)^{\alpha} + (IVPI)^{\alpha}\right)\right]^{\frac{1}{\alpha}}$$

Table 41.

Step 3. Interpretation of results

- Each of the vulnerability indices provides a value between 0 (zero) and 100 (one hundred per cent). Districts showing a composite vulnerability close to zero have the least vulnerability in relation to the other districts and those that tend towards a hundred have the greatest relative vulnerability. It is therefore possible to compare the vulnerabilities of different areas in the municipality.
- Vulnerability in the face of a threat is not a probability. In a social group, in a specific location within a municipality, vulnerability will be affected not only by social and economic elements (poverty, education and so on), but also by institutional aspects (i.e. building codes) and environmental elements, as has been pointed out throughout this manual.

This approach permits identification of the variable which carries most weight in the vulnerability, and therefore makes it possible to focus work on breaking the links in the cycles of aspects associated with poverty-disasters-environmental degradation and, therefore, plan by using those composite indicators as quantifiable goals to monitor the increase of resilience in the community.

These composite indicators also permit a concentration of social investment efforts (poverty reduction, literacy, infant feeding and so on), in order to achieve greater efficacy in the increase in resilience.

Maps showing VIVF and CVFI (versions a and b) results can be found below.

Which approach should be used; coded or calculated risks and vulnerabilities?

These methods are not exclusive, but complementary. The approach chosen depends on budget, information availability and the profitability of information detail. It is always advisable to balance the cost/benefit relationship of a greater amount of detailed information against the municipality's needs and priorities.

Some questions the SIGA can answer:

1 Which are the areas in the municipality that face the greatest risk in the event of a flood?

2 What kind of population (number, income characteristics, poverty, employment status, health, housing, etc.) is to be found in these risk areas?

3 Which are the most vulnerable social sectors in these areas? Where, specifically, are they located?

4 Which lifelines and services are likely to be affected?

5 Which are the potentially contaminating industries and where are they located?

6 What types of effluents are discharged into the watercourses? What areas may be reached by this source of contamination?

7 Which sector of the population is affected? Where is it located? How long will the population be exposed? Is the health of the population likely to be affected?

8. What kind of economic activity is likely to be affected? Which investments might be affected and what is their approximate value?

9. What is the historical record regarding this event in the area and what actions have been taken in the past?

10. What factors are increasing the poverty-disasters-environmental degradation cycle and on which locations could the municipality focus its work and centralize social investment projects?

11. How can qualitative and quantitative indicators be set up to monitor the evolution of vulnerability and risk?

Fig. 29. Victim Vulnerability Index by flood. Municipality of San José

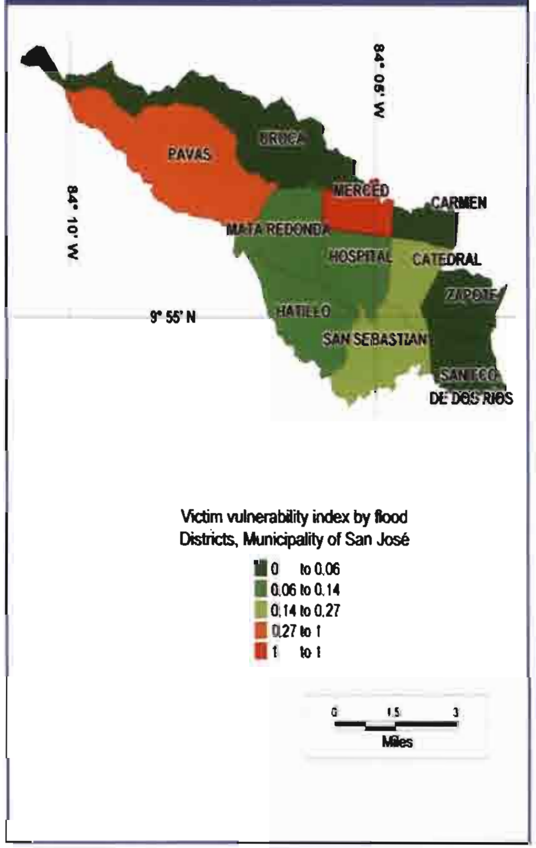


Fig. 30. Compound Vulnerability Index by flood (A). Municipality of San José

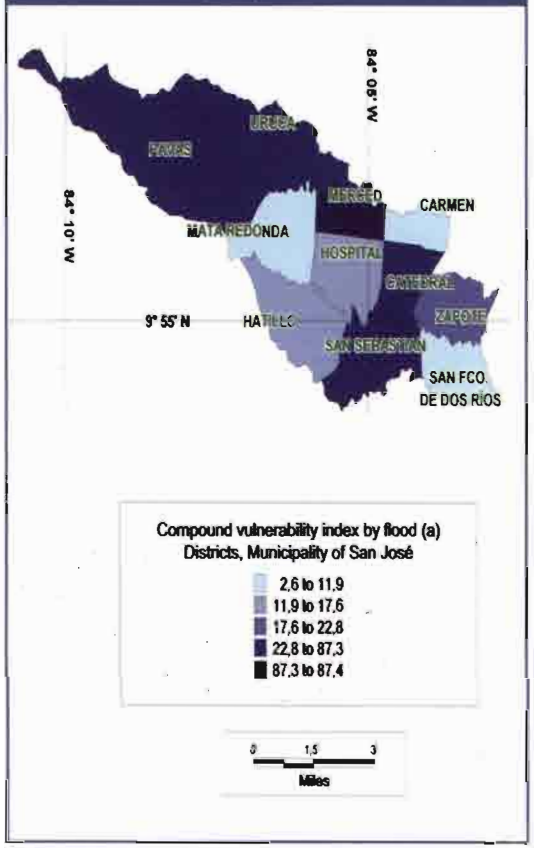
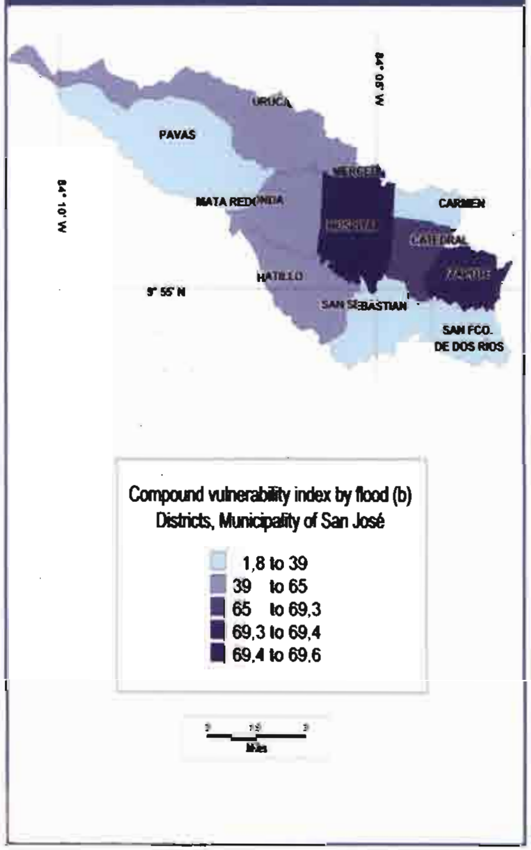


Fig. 31. Compound Vulnerability by flood (B). Municipality of San José



J- Decision-making process

Although it is true that, as stated above, the SIGA Manual is not devoted to the municipal decision-making process regarding vulnerability and risk reduction, different ways of using the information obtained in support of that process are shown below.

A goal for the municipality may be the reduction of vulnerability by means of the development of Investment in Prevention and Mitigation projects (IPM). The table below shows a hypothetical situation for the municipality of San José, in which information is given on municipal tax collection, investment in vulnerability reduction by district and the internal rate of return (IRR) for each of those projects. The IRR indicates the underlying profitability for each project and if it has been correctly estimated, it will reflect economic profitability. Therefore, the larger it is, the more socially profitable the investment (in this case) in vulnerability reduction. For further details regarding the variables, see the appendix on economic definitions.

PROVINCE	CANTON	DISTRICT	Investment m^2 index	Collection index	Prevention and mitigation investment index	International rate of return
San José	San José	Carmen	4,54%	3,51%	3,97%	0,12
San José	San José	Catedral	11,34%	14,62%	12,90%	0,10
San José	San José	Hatillo	11,34%	4,68%	0,40%	0,15
San José	San José	Hospital	9,07%	11,11%	11,90%	0,40
San José	San José	Mata Redonda	1,81%	2,34%	1,39%	0,10
San José	San José	Merced	6,80%	17,54%	19,84%	0,13
San José	San José	Pavas	18,14%	7,02%	7,94%	0,055
San José	San José	San Fco. De Dos Rios	4,08%	20,47%	19,84%	0,09
San José	San José	San Sebastian	7,94%	1,17%	0,99%	0,13
San José	San José	Uruca	11,34%	9,36%	10,91%	0,20
San José	San José	Zapote	13,61%	8,19%	9,92%	0,20

Table 41. Indicator of Investment in Prevention and Mitigation in the Municipality of San José.

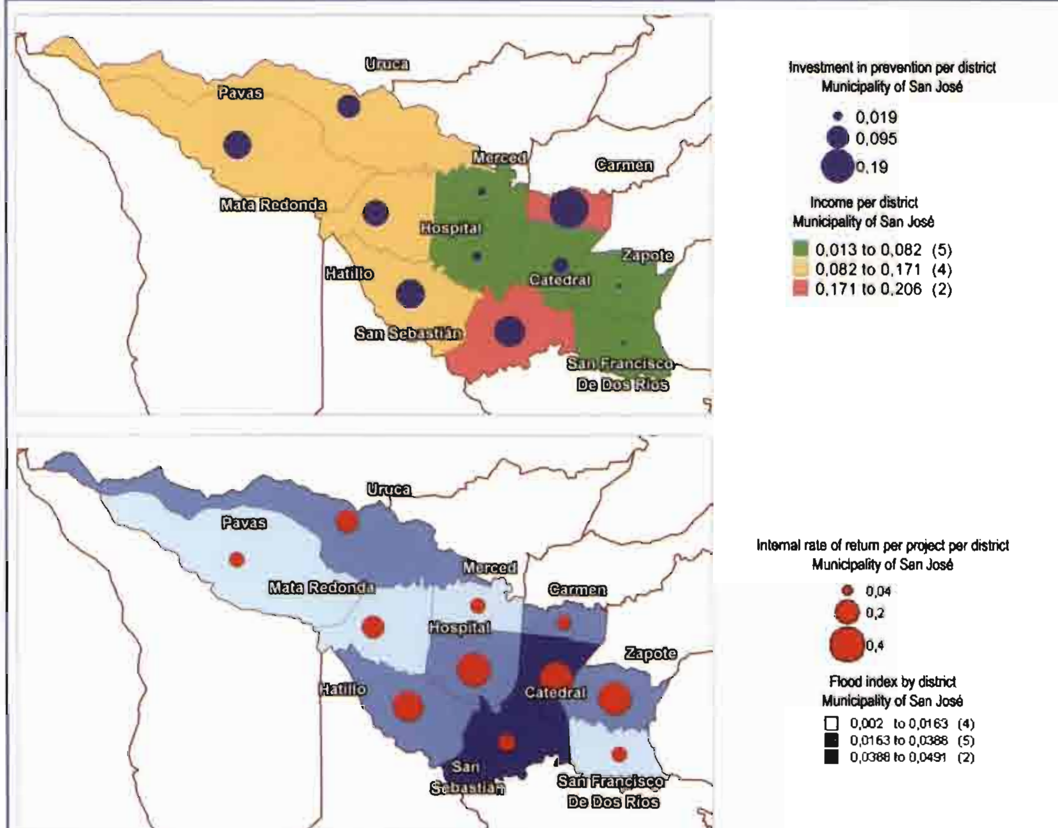
The maps included on the previous page show the results, according to an estimate of quantitative vulnerability. It will be noted that the greatest internal rates of return (IRR) are not necessarily always situated in districts within the municipality with the greatest social vulnerability. For example, see the poverty maps, which show that the largest poverty rates are in Uruca. This depends on the nature of the project, on the infrastructure, potential losses and on the degree of vulnerability reduction achieved by the investment. For example, in the case of the Hospital district, a high vulnerability does tend to match a high IRR.

Another interesting point is that the districts that show the highest IRR are not necessarily those in which the greatest income in municipal taxes is obtained. This may be due to low probability or risk of a threat in that district.

In other districts with lower tax contribution capacity, but greater flood indicators, the IRR is much higher (Zapote, La Merced, Hospital, etc.). If investment in prevention is used and put into practice according to IRR criteria, situations may arise in which the municipality's contributors who, on average, pay higher rates, may express their discontent. In other cases, the situation can derive in a middle ground: a medium IRR and high tax collection, as in the case of San Sebastián .

This hypothetical example shows the complementation of information required for decision makers in the municipality to use SIGA information and contrast it with the priorities of their administration and budget availability. Thus, they can determine in a transparent manner the criteria which will form the basis of their decisions on the location for investment in prevention and mitigation in some areas of their municipality.

Fig. 32. Hypothetical revenue collection map, investment in prevention and TIR by vulnerability reduction projects. Municipality of San José



Source: M. Adamson (2007).

K- Complementing SIGA capabilities across municipalities

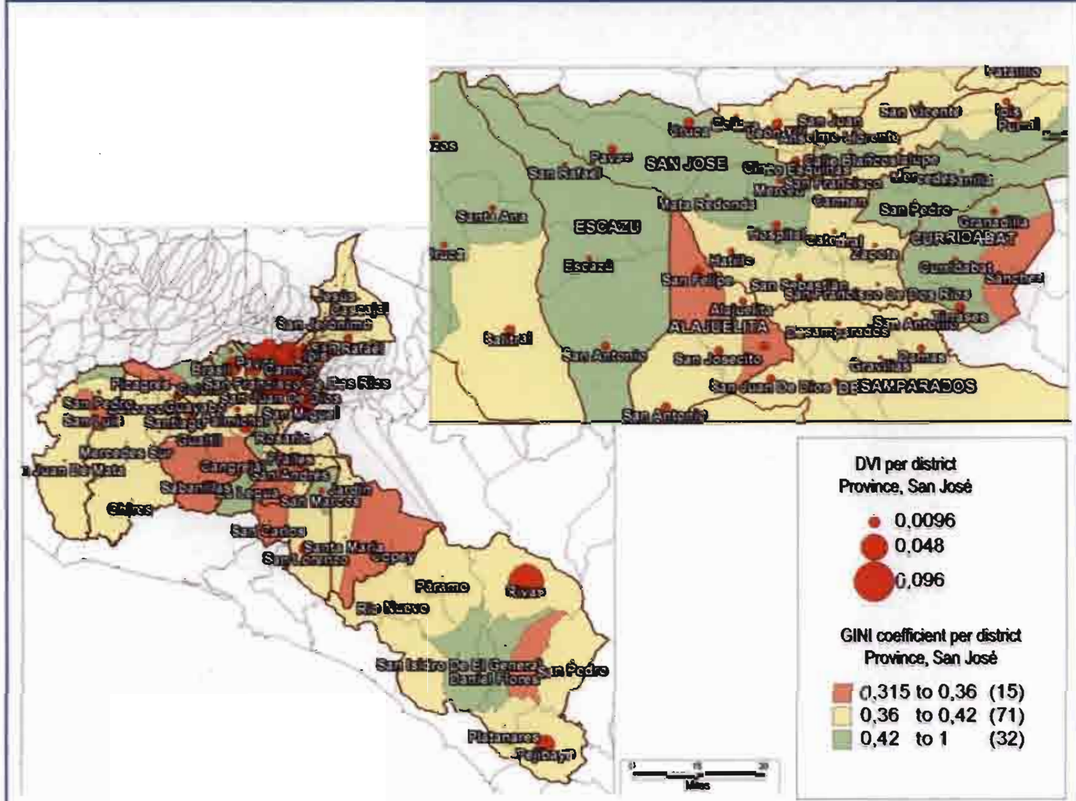
Once several neighboring municipalities have installed their SIGAs, they will be able to work together, increasing the levels of analysis and taking further advantage of the preventive investment made in the production of their SIGAs.

For example, it might be desirable to carry out a comparative analysis among various municipalities by type of vulnerability. In this case, the whole SIGA or just one aspect of it can be used. As an example, page 72 shows the vulnerability index for flood victims and the GINI coefficient for the municipalities (brown boundary line) in the Province of San José, Costa Rica. An enlargement is included of a section in the central territory, where the municipalities are smaller in terms of square meters.

In this case, the DVI (Disaster Victim Index) is calculated exactly as before, except that since a comparison among districts of the municipalities is desired, the minimum and maximum must be located for each of those districts. This makes it possible to obtain an indicator which provides an immediate comparison across all of the districts of the municipalities in that province.

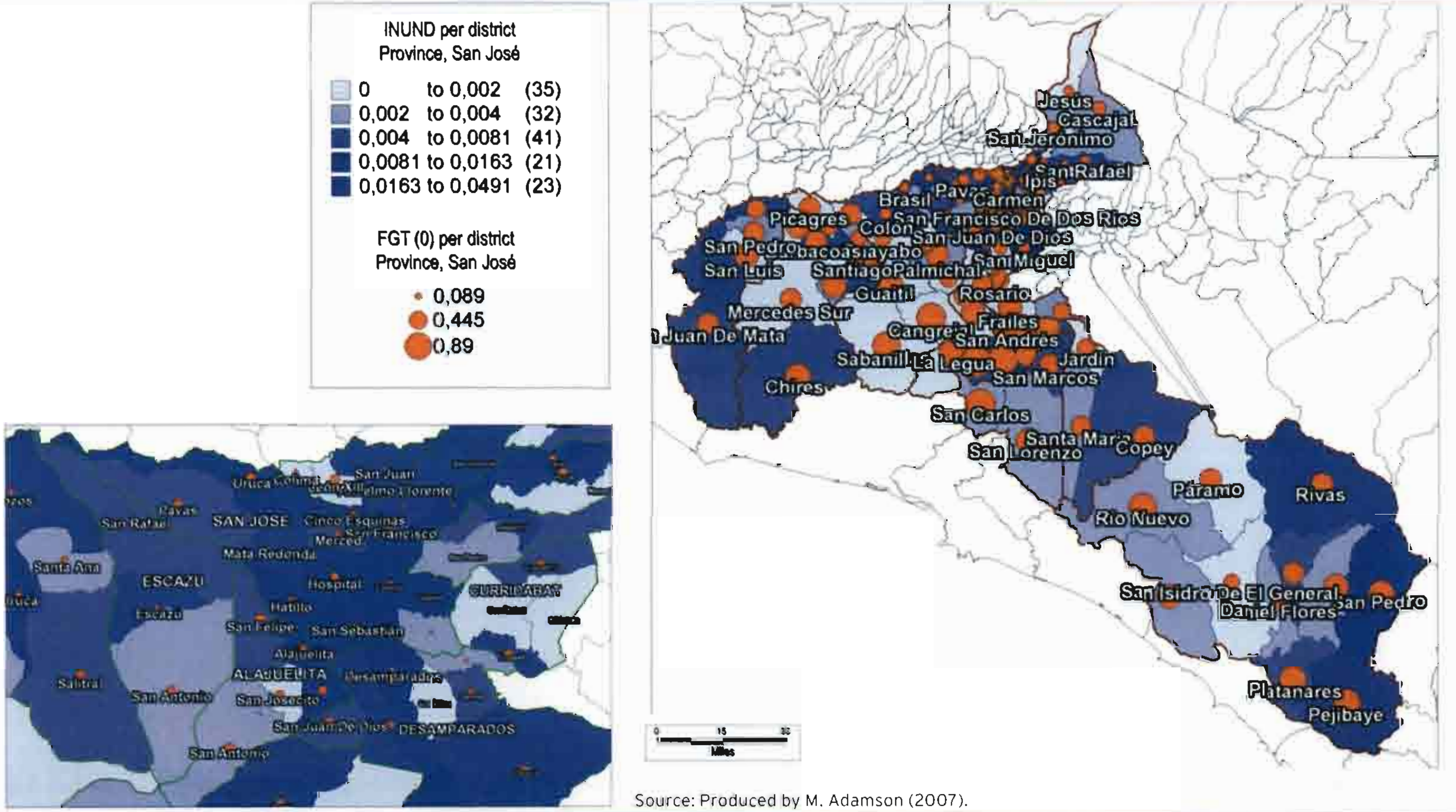
Likewise, next is a map showing the flood index (number of floods in district i/total number of floods) and the proportion of poor people in the municipality districts in the province of San José. Please note that in this case, in some districts a high flood rate coincides with a high proportion of poor people, particularly in the municipalities on the periphery. On the other hand, this ratio is not always present, as in the case of the municipalities in the interior. Therefore, the municipalities in the interior could undertake cooperation agreements, in cases in which they are jointly affected through being located in areas where basins are shared.

Fig. 33. Disaster victims index (DVI) and GINI coefficient, per district and municipality, Province of San José, Costa Rica

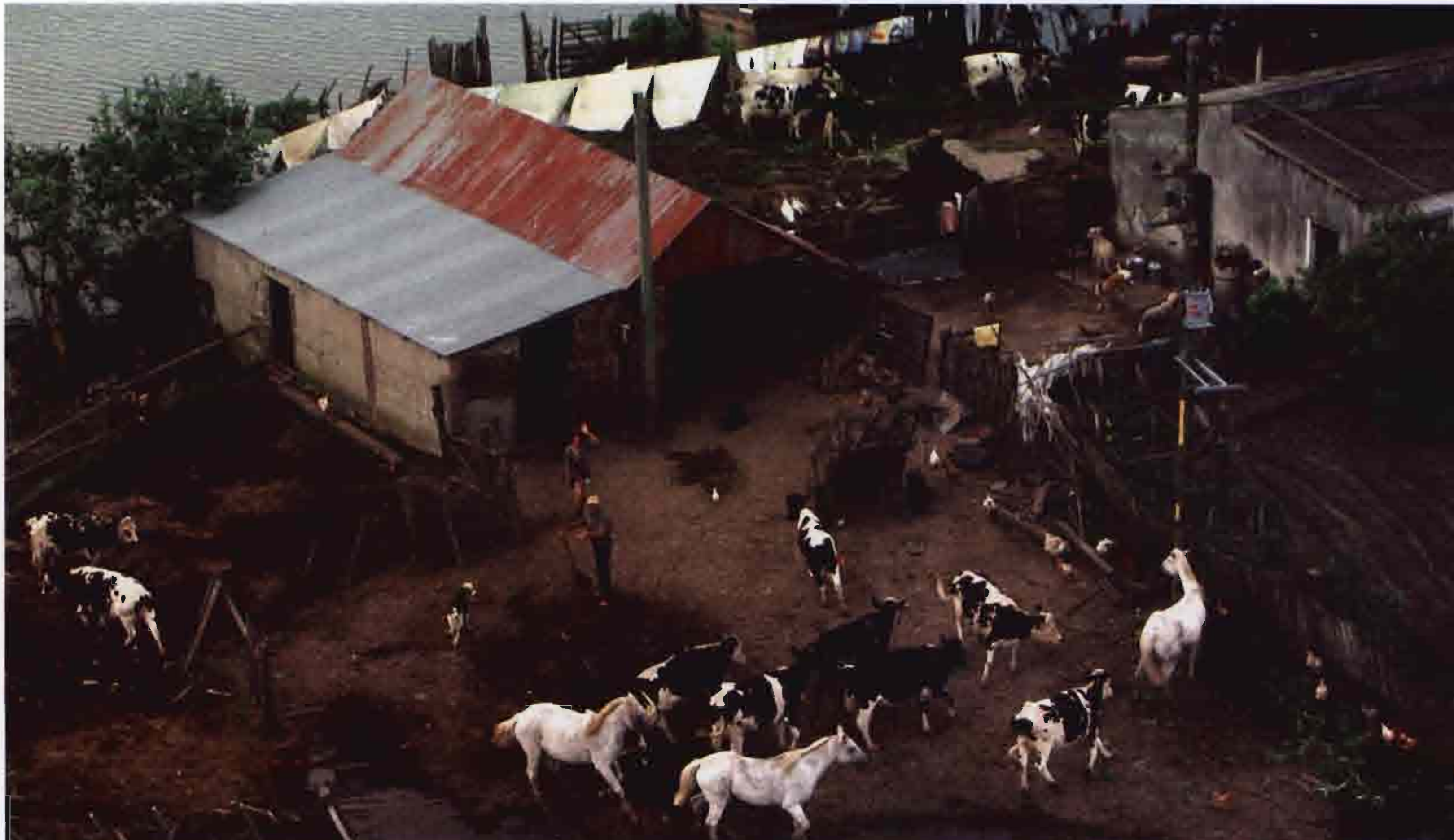


Source: Produced by M. Adamson (2007).

Fig. 34. Flood (INUND) and poverty (FGT [0]) indices per district and municipality in the Province of San José , Costa Rica.



Source: Produced by M. Adamson (2007).



An Exercise for the Preparation of the SIGA

(Basic Model and Qualitative Indicators)

Identification of threats
The SIGA typifies the geophysical system by means of five variables:

- Elevation
- Basins
- Geology
- Geo-morphology
- Hydric networks

For each, a table is drawn up, containing:

- A topological identifier—in this case, virtual—which in real cases will be used for the preparation of the database.
- An attribute corresponding to each variable.
- The degree of the threat in the face of the event.

The object is to determine the degree of exposure to the threat of flooding, for each of the four variables in the geophysical system. In each table, the level must be organized numerically, the indicator numbers being placed from lower to higher (0 - null; 1 - very low; 2 - low; 3 - medium; 4 - high; 5 - very high), according to how the threat affects the territory.

From the cross-referencing of the maps, a mosaic will result which will describe the level of the threat expressed territorially, in a similar format to that seen on the screen.

Elevation

Id_height	Depth (m)	Threat Level (TL1)
100	50	
101	500	
102	1000	
103	2000	

Geology

Id_geology	Type of predominant rock	Threat Level (TL2)
200	Granite	
201	Sandstone	
203	Limestone	
202	Gneiss	

Geomorphs

Id_geoforms	Major geoform	Threat Level (TL3)
300	Plain	
301	Concave slope	
302	Convex slope	

Hydric Networks

Id_network	Flow	Threat Level (TL4)
400	Standing	
401	Standing	
402	Intermittent	

By cross-referencing the previous tables, a composite topological code is obtained, as well as a composite threat indicator.

Threat Summary

Id_ height	TL1	Id geology	TL2	Id geo-forms	TL3	Id net-works	TL4	TL1,TL2, TL3,NA4	TL1+TL2+ TL3+TL4
100		200		300		400			
101		201		301		401			
102		202		302		402			

Socio-Economic System – Social Vulnerability

In this hypothetical case, the socio-economic system is synthesized in the SIGA by means of a summary of the following variables:

- Population
- Sex (men/women ratio * 100)
- Age (in the exercise, the 0-14 age group is considered)
- Health coverage (absence of coverage is also taken into account)
- Housing quality

By working with these variables, qualitative indicators of "social vulnerability" are established. Analogously to exercise 1, in each of the following tables the level is organized numerically, with indicator numbers organized from lower to higher

(1 - very low; 2 low; 3 - medium; 4 - high; 5 - very high), thus achieving a qualitative codification of these variables which it is hoped will summarize vulnerability. This example, therefore, uses this type of qualitative indicators and not quantitative social vulnerability indicators.

It is necessary to remember that socio-economic variable data are obtained from Population Censuses, and that the topological identifiers are those used by the relevant institution.

Population (Total population is 450 people)

Id_zone census	Population (population size)	Area (has)	Population Density	Code vulnerability CV1
400	400	400		
401	401	401		
402	402	402		

Age Group

Id_zone census	Population (population size)	0-14 years (age group by number)	% 0-14 years	Code vulnerability CV2
1562	150	40	40/150	
2398	200	35		
450	100	38		

Discrimination by Sex

Id_zone census	Population (population size)	Men	Women	Masculinity Index	Code vulnerability CV3
1562	150	80	70	(80/70) *100	
2398	200	95	105		
450	100	60	40		

Health Coverage

Id_zone census	Population	0-14 years Nº without security coverage	0-14 years olds % without coverage	Code vulnerability CV4
1562	150	14		
2398	200	23		
450	100	5		

Housing Quality

Id_zone	Nº Housing	Nº Poor quality housing	Poor quality % Housing	Code vulnerability CV5
1562	78	20		
2398	50	40		
450	36	2		

Result of the Social Vulnerability Code

Id_ zone	CV1	CV2	CV3	CV4	Composite Indicator (cv1,cv2, cv3,cv4)	Indicator additive (cv1+cv2+ cv3+cv4)
1562						
2398						
450						

In order to obtain the potential risk, the degree of Threat (TN) must be cross- referenced with the Vulnerability code (VC), as a first approximation.

Potencial Risk

Id_ height	Compound (TL)	Id_zone	Compound (CV)	**Potential Risk**
100		1562		
101		2368		
102		450		

Use of Land

In this exercise, the main uses of the land and how these uses are affected by threats are determined. As in the previous exercises, the uses are organized by numerical indicators (1 - very low; 2 - low; 3 - medium; 4 - high; 5 - very high). This makes it possible to determine the type of environmental conflict produced by anthropic activities, which will reduce or increase the potential risk obtained in exercises 1 and 2.

Use of Land

Id_land uses	Land use	Responding to the threat
10000	Irregular Housing	
20000	Particular Housing	
50000	Hortofruticul Orchard	
80000	Industrial Manufacturing	
80001	Industrial Cultivation	
85000	Heavy Industry	
107	Green Spaces	

Lifelines and Services

Road network

Id-Roads	Type	Risk Facing Threat
100000	Route	
100001	Neighborhood	
100003	Path	

Sanitation System

Id-Sanitation	Height (cota)	Risk Facing Threat
20000	10	
20001	500	
20003	100	

Electric Power

Id-Height	Height (cota)	Risk Facing Threat
30001	10	
30002	500	
30003	100	
30004	2000	
30005	2300	
30006	1000	

Health Services

Id-Health	Height (bench mark)	Existence	State	Vulnerability
40000	10			
40001	500			
40002	100			
40003	2000			
40004	2300			
40005	1000			

Education

Id-Education	Height (bench mark)	Existence	State	Vulnerability
50000	10			
50001	500			
50002	100			
50003	2000			

Communications

Id-Education	Height (bench mark)	Existence	State	Vulnerability
60000	10			
60001	500			
60002	100			
60003	2000			

Satellital image of Buenos Aires City and suburb. International Space Station (ISS).
Date 08/02/2003.
Source: http://caece.edu.ar/tea/imagenes.htm

4. USE OF SPACE AND SATELLITE TECHNOLOGY AND NEW LOCAL PRACTICES IN RISK MANAGEMENT AND VULNERABILITY REDUCTION

At present, the significant investment which agencies make in space and satellite technology, is not only justified from the point of view of attention to disasters and the importance of access to information in the least possible time, but also because investment is currently more and more justified mainly from the point of view of prevention.

Space and satellite technology provide a large and diverse amount of information deriving from various remote sensors, which can be stationary or mobile—for example, sensors can be placed on ships and cars or air-borne in aeroplanes, helicopters, satellites and so on.

Satellite sensors make it possible for continuous monitoring of different elements such as land use, tree coverage, crops, urban areas, maritime-terrestrial areas, bodies of water, and so on. Visual information is often resorted to—photographs or images—which may be taken from the air or from satellites. This real-time monitoring may be carried out on a daily basis, or even provide an almost instantaneous view of an area, depending on the location of the sensors and receptors.

As using the Geographic Information System (GIS), became more popular, municipalities acquired greater experience in the use of this tool and included the type of information derived from the system in municipal tasks. For example, in Costa Rica, several municipalities (San José, Escazú, Barba, etc.) are making progress in this respect. Furthermore, a significant number of municipalities include this information in the management and monitoring of building permits.

More recently, space technology has become a significant tool for municipalities. In particular, in activities related to improving municipal rate collection, mainly through the application of GIS in territorial tax collection processes. The municipality can, by means of images with the appropriate resolution, determine the exact size of properties, their condition, the actual use given to the land, types of structure, and so on. This way, they can update their valuation platforms and monitor tax collection based on updated information.

Fig. 35. Illustration of a satellite sending information.

Fig. 36. Actual color photograph, ADS 40 digital camera.

This technology also provides a significant source of updated information available to the different units of the SIGA.

Until recently, cadastral procedures were carried out by the municipalities, which, at best, had to spend large sums on aerial photography. The expenditure was high since it had to cover flight planning, the flight itself, fuel, as well as analogue film, adequate storage, manual processing in orthorectification (in order to produce digital elevation models–DEM–for example).

All of this represented a significant financial barrier for municipalities wishing to incorporate information obtained by space and satellite technology. Usually, the cost/benefit ratio of these procedures for the acquisition of information was not attractive.

At present, with the advent of precision digital cameras, it is possible for municipalities to receive digitized and orthorectified products directly from only one fly-over. Everything is done in the same procedure and at a much lower cost than with the analogue process, a fact which has allowed municipalities increasingly to include this technology and its products, particularly digitally photographed images in real color.

By using this technology, municipalities can develop a wide variety of projects; environmental studies, urban planning, use of land management, national park management, hydrological models, hydrological studies and planning, plans for urban and agricultural use of land, transport studies, mapping, cadastral systems and valuation platforms, topographic and relief maps, cartography in general, and, of course, applications for the management of emergencies, risk management, and prevention and mitigation planning, among others.

In addition to the information provided by color images, municipalities have recently begun to use more specialized information, such as infrared images or information derived from spectral sensors–of up to fifty light spectrum bands–and even hyper spectral information–over two hundred bands–which provide a variety of information, such as quality of the water, identification of materials, landslide studies, flooding, faults, etc. All of these may be used to carry out detailed classification of land use, type of forest, volcano emission analysis, etc. Furthermore, municipalities are using the information derived from radar sensors, which can provide details of flooded areas even in conditions of dense cloudiness.

Fig. 37. Merge of infrared images of the Greater Metropolitan Area of Costa Rica. Source: Presentation by R. Rodríguez, 2006.

Fig. 38. Infrared photograph of a flood in Costa Rica in 2003. Source: CONARE-CENAT, 2003

In addition to the information provided by color images, municipalities have recently begun to use more specialized information, such as infrared images or information derived from spectral sensors–of up to fifty light spectrum bands–and even hyper spectral information–over two hundred bands–which provide a variety of information, such as quality of the water, identification of materials, landslide studies, flooding, faults, etc. All of these may be used to carry out a detailed classification of land use, type of forest, volcano emission analysis, etc. Furthermore, municipalities are using the information derived from radar sensors, which can provide details of flooded areas even in conditions of dense cloudiness.

The increased application of satellite technology to municipal procedures and tasks –from risk prevention and management, to the management of municipal finances– and the accelerated substitution of aero-transported technology, is the result of the lower cost per square meter of satellite technology. The cost is lower compared to aero-transported technology, even with the latest technological progress made in the latter. The cost of planning flights and of the flights themselves is a financial barrier which is not easy to overcome and justify by means of photographs which will soon be outdated. The advantage of satellite technology is precisely that it makes it possible to obtain updated information at a very low cost per area.

It is still true, however, that for some specific engineering projects which require extremely high resolution –for electric power transmission pylons, for example– aero-transported technology can be appropriate. However, even in such cases, satellite technology is showing really significant progress, which in the medium term will provide interesting substitutes, at a lower cost per square meter, due mainly to economies of scale

Fig. 38.
Source: CONAE.

At present there are various options for acquiring information, both from government-owned and privately-owned satellites. In Latin America, countries such as Argentina and Brazil have their own satellites which provide information. Venezuela has also announced the imminent launching of its own satellite, and missions continue to make progress.

For example, in the case of Argentina, the National Commission for Space Activities (CONAE) has made a significant effort to make the satellite information generated by SAC-C satellite available to provinces and municipalities. Among other purposes, this satellite obtains information for the management of emergencies.

The plan is part of that country's Federal Emergency System (SIFEM in Spanish). For example, the website http://www.conae.gov.ar shows the valuable contribution made by space information to the process of managing emergencies. It is possible to evaluate the success of the space information service in the management of emergencies in this case, through the significant increase in the demand for satellite and space information by municipalities and other users.

An interesting case, which occurred during a slow-evolving disaster, was the El Niño 97/98 event, which showed, on the one hand, the potentially strong demand from user institutions and municipalities, and, on the other, the usefulness of the service. Because of this, CONAE devised a simple and efficient procedure for the provision of space information at no cost. During that event alone, final demand was for 100 images a month.
In accordance with the hypothesis that every offer creates its own demand, there was also an increase in the number of users and institutions which prepared products with a greater added value, required in the decision making based on those images. Demand grew from 10 in 1998 to over 70 in 2002.

Fig. 39. Source: CONAE and NASA.

At present, CONAE is making progress in the development of its next satellite, SAC-D. As the diagram shows, it will provide important information about salinity, climate monitoring and environmental disasters; it will make it possible to estimate crops, detect fires, air and water pollution, ground humidity and so on.

The availability of this kind of information is strengthening risk management, as well as the management of disasters in regions and municipalities. By way of example, the type of product this kind of technology generates is shown below, for a real case, in the province of La Pampa, in Argentina.

Fig. 40. Modeling a flood threat in the province of La Pampa. Argentina.

Source: CONAE, 2005. MP Training Course. International Charter and CONAE.

International Charter: Space and Major Disasters

The International Charter is a mission which includes space agencies and organizations (the European Space Agency, the French, Argentinean, Japanese and Indian agencies; the Geological Service and the National Ocean and Atmosphere Administration, of the United States).

Its aim is to provide, through Authorized Users, a unified system for the acquisition and delivery of space data, devoted to areas affected by great natural or anthropogenic catastrophes. Each member agency has committed resources in support of the provisions of the Charter, thus, helping mitigate the effects of catastrophes on the lives of people and on goods.

The International Charter officially came into effect on November 1, 2000. An Authorized User can now request, by means of a simple phone call, the mobilization of related space and terrestrial resources (such as RADARSAT, ERS, ENVISAT, SPOT, IRS, SAC-C, and the NOAA and LANDSAT satellites) of the agencies in order to obtain data and information regarding a catastrophe.

An operator (a 24-hour service) receives the call, verifies the identity of the applicant and checks that the User Request form sent by the Authorized User has been correctly completed. The operator then transfers the information to the Emergency Duty Officer, who will analyze the request and the range of the catastrophe with the Authorized User and will prepare a file and a plan of acquisition by means of the available space resources. The acquisition and delivery of the information is carried out on the basis of an emergency criterion, while a Project Director, who is qualified to organize, handle and apply the data, will guide the user through the whole procedure.[1]

In Latin America, the Charter has been activated in support of regions and municipalities affected by great disasters, with the participation of the National Commission for Space Activities (CONAE) and the Federal Emergency System (SIFEN) of Argentina. Examples of activations in Latin America have taken place in countries such as Venezuela, Colombia, El Salvador and Argentina.

Fig. 42. Thematic satellite products of remote optic sensors.
Zone 3. Municipality Gamarra, Department César, Magdalena River

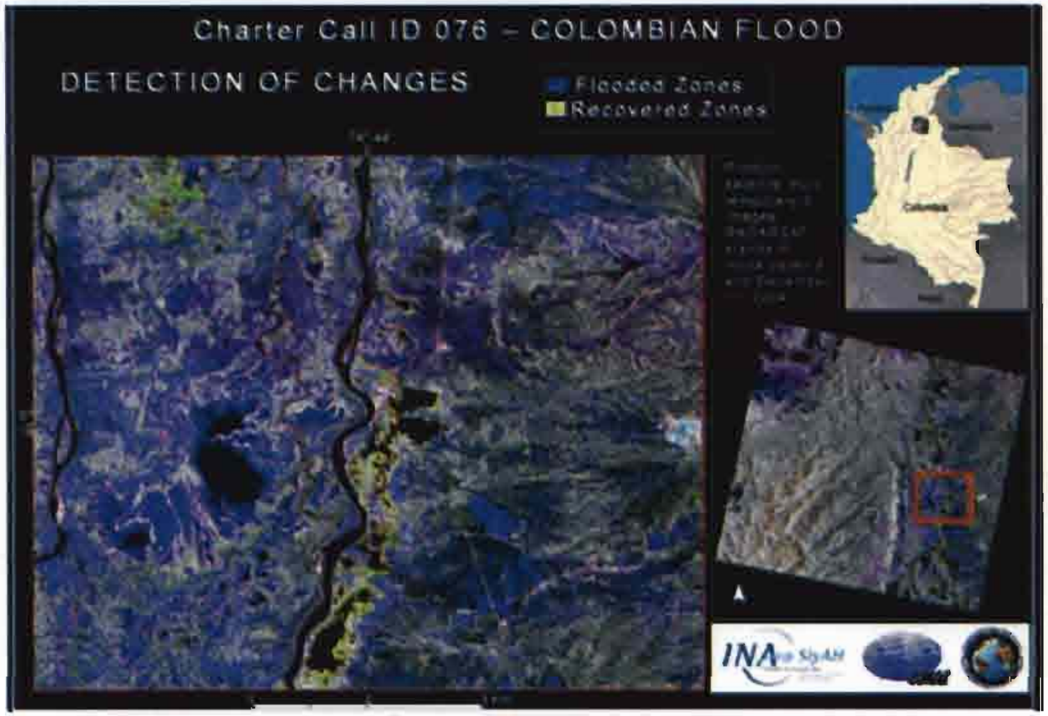
Source: Translated from the Spanish version (Álvaro Soldano; National Water Institute; Project Manager (Floods) International Charter. Presentation: INTERNATIONAL CHARTER: "SPACE AND MAJOR DISASTERS", at the Teófilo Tabanera Space Centre (CETT). Regional Seminar, April 21st and 22nd, 2005. CONAE. Córdoba, Argentina).

[1] Taken from www.disastercharter.org

The areas projected for damage assessment were situated in the NE of Colombia. The affected regions were grouped in the Project in three (3) areas. Each area is a circle with a 30 km radius:

- Municipality of Guaranda - Department of Sucre, Río Cauca, Colombia. Geographic Coordinates: 08° 28', -74° 32'.
- Municipality of San Pablo - Department of Bolívar, Río Magdalena, Colombia. Geographic Coordinates: 08° 20' N, -73° 45.
- Municipality of Gamarra - Department of Cesar, Río Magdalena, Colombia. Geographic Coordinates: 07° 30' N, -73° 55.

Fig. 43. Thematic satellital products of remote optic sensors.
Zone 3. Municipality Gamarra, Departament César, Magdalena River



Source: Translated from the Spanish version (Álvaro Soldano; National Water Institute; Project Manager (Floods) International Charter. Presentation: INTERNATIONAL CHARTER: "SPACE AND MAJOR DISASTERS", at the Teófilo Tabanera Space Centre (CETT), Regional Seminar, April 21 and 22, 2005. CONAE. Córdoba, Argentina).

As observed, the technology made possible by the Charter generates very valuable information which makes it possible to manage the disaster. The value of the information very often amounts to several hundred million dollars. It is to be hoped that space technology will continue to develop, and that municipalities will therefore find it possible to include it more and more in their tasks and responsibilities; above all, in risk management and vulnerability reduction.

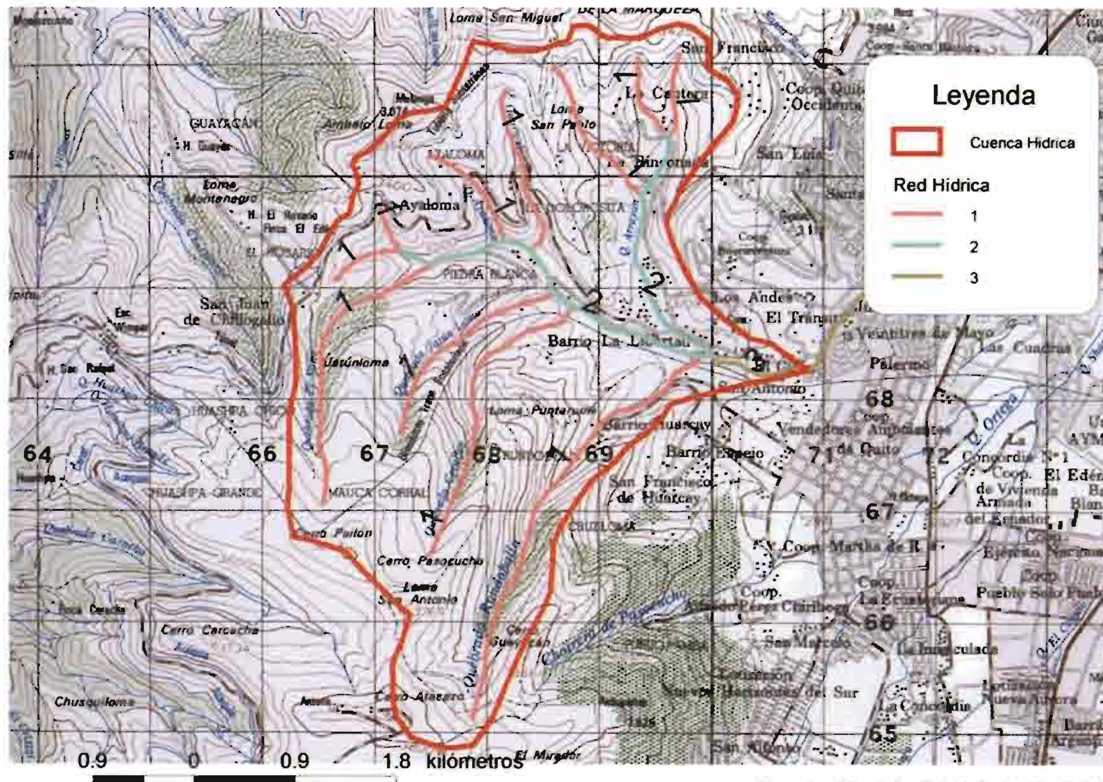
Fig. 44. Activation in Venezuela. February 2004

Source: Translated from the Spanish version (Álvaro Soldano; National Water Institute; Project Manager (Floods) International Charter. Presentation: INTERNATIONAL CHARTER: "SPACE AND MAJOR DISASTERS", at the Teófilo Tabanera Space Centre (CETT). Regional Seminar, April 21 and 22, 2005. CONAE. Córdoba, Argentina).

APPENDICES

Basic concepts

A hydrographic basin is a spatial unit consisting of a great diversity of biotic and abiotic factors which interact with each other. Solar energy and precipitations constitute the main "input" of energy, matter and information which unleash processes and interactions between the elements of the hydrographic basin, from which "output" responses are generated, depending on internal structures and dynamics. The hydrographic basin acts as a "systemic operator", so that any qualitative and/or quantitative alteration produced in the input will influence both the global function and its sub-system components (Achkar et al, 2004[1]).



Fuente: Municipalidad de Quito (2005)

Figure A1.

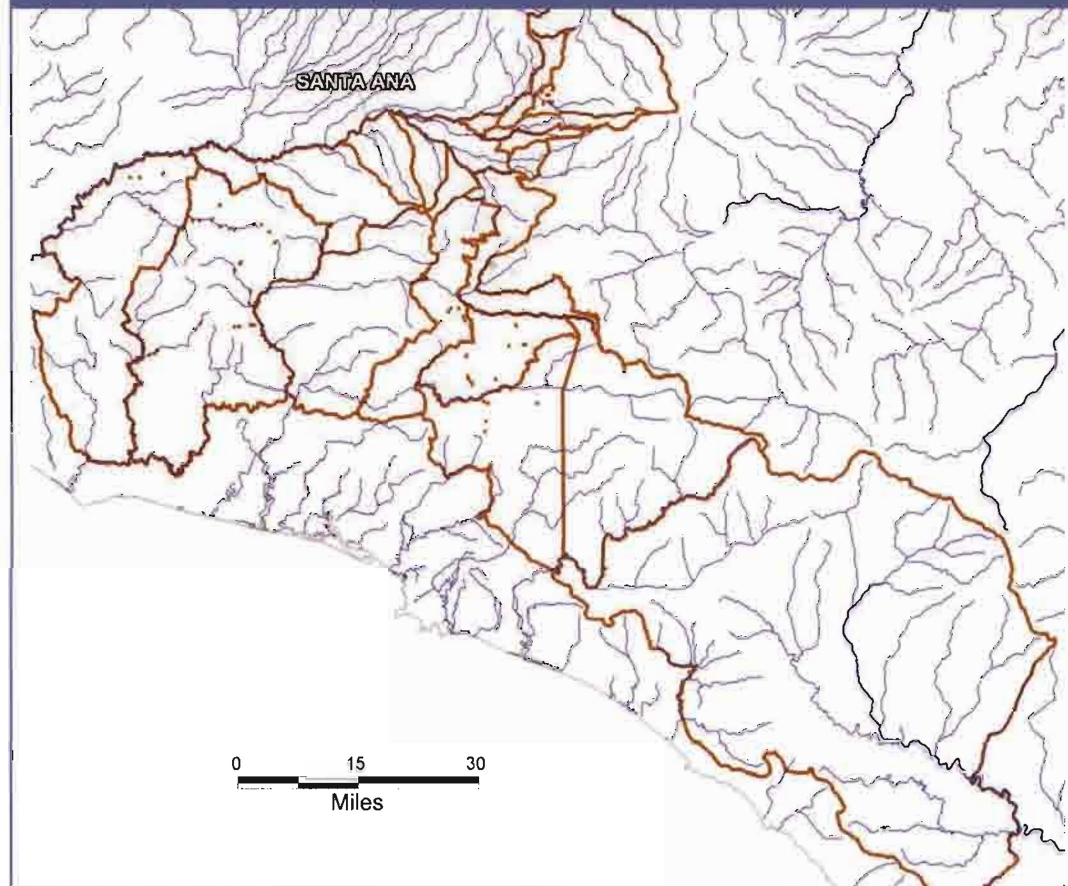
[1]. Achkar et al - Hacia un Uruguay Sustentable. Gestión Integrada de Cuencas Hidrográficas 2004. ("Towards a Sustainable Uruguay. Integral Management of Hydrographic Basins 2004").

A hydrographic basin is by definition an open system, in which interactions take place between physical and natural factors, a society which transforms it internally, and makes it possible to identify external interactions. Internal and external interactions influence and favour specific land uses, which, together with the infrastructure, make up the visible landscape.

The basin's geographical area is subject to modifications due to changes in the elements mentioned above and their interactions, as well as to the influence of external factors –climatic and tectonic– and internal ones –economic activities, socio-cultural characteristics, institutional aspects– which generate risk. This territorial unit is appropriate when planning preventive measures within the framework of sustainable development, in as much as the basin is the territory's functional unit.

This implies developing the capacity for coordination of the administrative units (departments or municipalities) within these territorial units, in terms of managing environmental risk. In the vast majority of countries, it is the courses of the rivers themselves that have been used as boundaries between different municipalities and/or districts.

Fig. A2. Municipalities and drains of the Province of San José



An example of this situation is given below, with a map of the main rivers and municipalities of the Province of San José, in Costa Rica. As can be seen, watercourses delimit most of the municipalities. This calls for a great capacity for coordination among municipalities, providing as it does a good opportunity for cooperation in the vulnerability and risk reduction, by means of the SIGA, as was shown above at inter-municipal levels.

Threat, Risk, Vulnerability and Resilience

Threat/Danger: Understood to be the potentially damaging existence of a physical or technological event, or a combination of both, which can cause loss of life or injury, or material damage, and affect the socio-economic or environmental system. Threats include latent conditions which might materialize in the future.[2]

They may be of different natural (geological, hydrometeorological and biological) or technological origin—resulting from the use of man-developed technology. Within the latter are included technological threats such as the explosion of a chemical or nuclear plant. There are also threats which are caused by a combination of factors; for example, those which are linked to environmental contamination and degradation of natural resources, such as a flood which, although it may be due to heavy rain, is accentuated by the elimination of forests in a steeply sloping area, resulting from farming customs and technologies.

Natural threats originate in the dynamics of the earth´s crust, or the atmosphere (for example: earthquakes, volcanic eruptions, hurricanes, tsunamis, torrential rains). For the purposes of the project they are sub-divided into hydrometeorological and tectonic threats.

Technological threats can be directly attributed to the application of technology developed by man during the course of his daily activities (production, housing, leisure, consumption and so on), which can affect the quality of the environment or natural resources and the very welfare and quality of life of the population. For example: the discharge of solid or effluent waste, which causes water contamination; emission of contaminating particles in the air, which causes respiratory diseases; death by war; productive or urban patterns which degrade the river banks and/or increase superficial overflow through urbanization, thus causing floods and aquifer contamination; contamination of freshwater layers through the intrusion of salinity, leading to a deficit of fresh water, etc.). Technological threats are clearly mainly linked to two broad factors: the availability of technology and the use which society makes of it.

Risk: The quantitative or scientific definition of risk indicates that it is the probability of a threat or latent danger materializing. The concept of risk has an ex ante meaning; that is, before the event materializes, since when the event occurs, its probability is equal to the actual event; that is, it is a certainty.

This probability can be determined either by means of historical or scientific information about the behaviour of the type of threat, or by means of probabilistic models. Furthermore, the risk can be

2. Taken from the Hyogo Action Framework for 2005-2015: Increase of the resilience of nations and communities in the face of disasters, based on the ISDR of the United Nations, Geneva. In A/CONF.206/L.2005.

quantified on a subjective scale—which can even by coded to represent the perceptions of a group or of an individual, and therefore approximate a subjective probability by type of threat. In this latter case, probability depends upon individual and collective perceptions, motivations and attitudes, and does not necessarily coincide with the scientific-technical perspective, but it is very relevant, in particular in the making of decisions about planning, as it stems from the interaction of people with the environment. Such interactions are the result of reality and not simplifications resulting from idealizations, as scientific models are, which implies that the latter can be and are subject to overlooking certain relevant aspects.

Social perceptions of risk are not free from error, such as when they are the product of imaginary perceptions, or expectations founded on events that are not entirely true or well-grounded on fact.

On the other hand, in social terms, progress has been made in the conceptualization of risk, inasmuch as threats generate interest if they pose a latent danger to a particular social group. It is clear that the impact of a threat on a social group depends on the factors that may lessen or increase the realization of the danger. Therefore, social, environmental and natural factors come together to produce an integral concept of risk. In the same way, when this integral concept must be measured together with others, it requires much more detailed probabilistic models, and greater amounts of information on those sectors, for its evaluation.

Which should be chosen? The principles of uncertainty and irreversibility indicate that more information is always better than less, in particular in the case of threats that could affect human life and development. Therefore, a complement to the information available will always be the better choice.

Vulnerability to Disasters: based on social conditions (such as levels of poverty), economic conditions (average income and productive models), environmental conditions, as regards natural and institutional resources (existence of structural codes, regulation of urban concentrations, etc.), all of which increase the susceptibility and exposure of a community, and therefore, the effect or potential impact of a threat[3]. Vulnerability is closely linked to the risk of a specific threat occurring, for the natural environment and the socio-economic system. Its measurement is not probabilistic. Rather, it is related to the conditions mentioned above and can be determined in terms of percentages; for example, from zero to one hundred percent, in which latter case the vulnerability is greatest in comparison to other locations.

Environmental Vulnerability is given by a combination of relationships, behaviours, knowledge and beliefs, which place people and communities in an inferior condition when faced with a threat.

Cultural Vulnerability is given by a combination of relationships, behaviours, knowledge and beliefs, which place people and communities in an inferior condition when faced with a threat.

Social Vulnerability refers to the social conditions of human welfare and development within a community which determine and condition its capacity to procure opportunities to achieve adequate and safe housing levels, safe sanitary levels, minimum levels of education and knowledge regarding threats, levels of organizational capabilities in the face of such threats, etc.

Physical Vulnerability is related to the physical location of human settlements, road infrastructure and lifelines (electricity, sanitation, water) and the technical quality or condition of housing materials. For example: location of villages in areas with a high risk of flooding or landslides.

Structural and Non-structural Investment: Structural investment consists of building and/or restructuring to reduce the possible impact of threats. Non-structural investments are those related to policies, awareness-raising, development of knowledge, public commitment, operational methods and practices, including participation

[3] Taken from the Hyogo Action Framework for 2005-2015: Increase in the resilience of nations and communities in the face of disasters, based on the ISDR of the United Nations, Geneva, 2004.

mechanisms and the supply of information, which can reduce risk and its related effects[4].

Resilience: The capacity of a system, community or society which is potentially exposed to threat, to adapt, by resisting or changing, in order achieve or maintain an acceptable level of operation and structure. It is determined by the degree to which the social system is capable of organizing itself in order to increase its capacity to learn from past disasters and in order to protect itself better in the future and improve risk reduction measures.[5]

Economic Loss nominal vs. constant: Economic loss provides an economic valuation of the impact of a disaster on a social group within a specific economic context. Nominal losses are valued at market prices; that is, they are measured by prices which the market establishes within a certain period of time; for example: the valuation which can be made of the different materials with which a bridge was built; as time passes, the price of those materials may fluctuate—either rise or fall. In that case, the loss (or the affected percentage) of the bridge can be valued at the price it would cost to rebuild at the present time (with a replacement criterion), with the same materials but at current prices, as an approximation of the opportunity cost of those resources.

If an accountancy valuation is carried out, the book value of the asset is taken—which implies that depreciation of the asset (the bridge) through use has been deducted, as well as its recovery value, so it is important to consider these factors in a more detailed analysis.

Constant economic losses are differentiated because they are valued using the prices in a base year. This makes it possible to make a comparison between different periods and determine which events generated the greatest losses. In practical terms, a base year is taken and the series of values is deflated by applying the implicit index in the Gross Domestic Product (GDP).

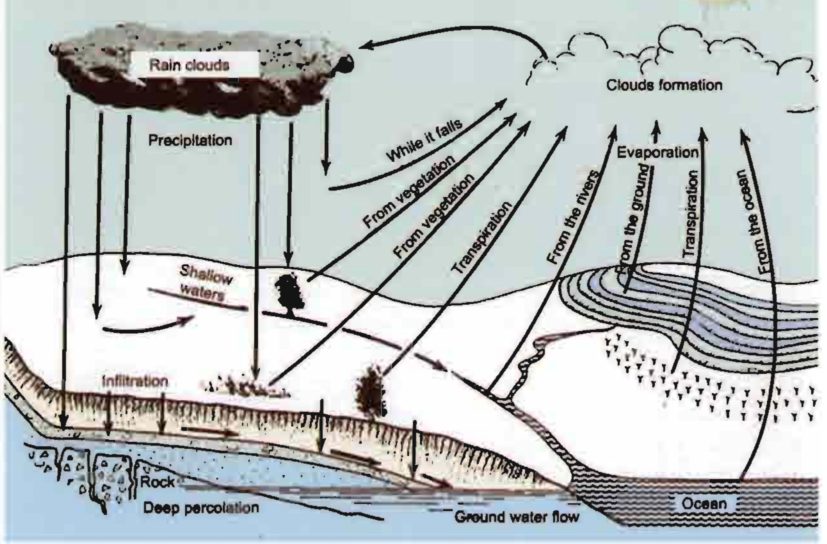
4. Op cit.
5. Op cit.

Source of Information

Table A1. Municipal Cartographic Inventory				
CARTOGRAPHY	FORMAT	CARTOGRAPHIC SCALE	COORDENATES SYSTEMS	DIGITAL COVERAGE
Urban Infrastructure	Digital Paper	1/ 50.000 1/20.000 1/10.000	Geographic (latitude longitude) Cartographic (X/Y)	polygon *** lines
Cadastral records (urban/rural)	Digital Paper	1/10.000 1/5.000 1/1.000	Geographic Cartographic Nomenclature (streets)	polygon *** lines
Rural Infrastructure	Digital Paper	1/50.000 1/10.000	Geographic Cartographic	polygon *** lines
Urban sewerage network	Digital Paper	1/25.000 1/10.000 1/5.000 1/1.000	Geographic Cartographic	polygon *** lines
Urban transport network	Digital Paper	1/10.000 1/5.000 1/1.000	Geographic Cartographic	Lines
Public Services (Central and Municipal Government)	Digital Paper	1/10.000	Geographic Cartographic	Dots

*** This type of coverage is recommended when the digitization of existing information on paper is to be carried out.

Fig. A3. Hydrologic cycle



Almost all the water is concentrated in the oceans. Solar energy transforms part of this liquid water into water vapor. Mere heating motivates the elevation of humid air to colder zones where it transforms into clouds. Clouds also contain fine dust, sea salt particles and other extraneous particles. When the clouds cool, raindrops are formed around these extraneous particles which serve as nuclei and fall to the ground. As they fall, they absorb carbon dioxide and other particles. The rain that falls to the ground seeps down, it runs off along the ground, or it is immediately absorbed by plants. Finally, much of the water that falls on the Earth's surface converts into water vapor and returns to the water cycle.

Table A2. Principal Geo-morphological Structures					
Erosion					
Erosion Method		Forms of Erosion	Method	Deposition Cause	Nature of Deposits
Mass Movements	-Slump -Landslides -Avalanches -Displacement -Rockfalls	-Moraines -Rock-fall scars	Slumping Rock falls Avalanches Landslides Plastic flow Soil creeping	Slope decrease obstruction Water seepage	Talus cones Rock glaciers Mud outflows Granite deposits
Surface water	-corrasion -corrosion -Hydraulic effect	Fluvial valleys Pediment Peneplains Fluvial terrace Wadis (in deserts) Giant marmites Potholes	Suspension Dissolution, saltation Rolling Push and drag	Speed reduction Slope decrease Volume reduction Channel changes Obstacles to circulation	Alluvial fan Banks Riverbed filling Alluvial terrace Deltas Levées Alluvial plain deposits
Wind	Deflation Corrasion Abrasion Impact	Truncated hills Hollowed rocks Mesa shaped rocks Rounded rocks Desert varnish Reg (rocky desert)	Saltation Suspension Rolling	Loss of speed Accumulation of heavy particles Rain	Loess Volcanic ashes and volcanic dust Dunes (barkhane, longitudinal, transverse, seif, parabolic
Glaciation	Extraction (plucking) Abrasion, scouring	Striation and ridging. Drumlins Polished surfaces. Crescent-shaped markings. U-shaped valleys. Truncated spurs Glacial cirques. Hilled fjords Crests. Horns	Suspension Plucking Surface transport Pushing	Ice fusion Breakage of ice in the ocean	Tills, moraines (lateral, terminal, recess, medial, foundation) Eskers, Kames, Kame terraces Glaciofluvial deposits Varves, Erratic boulders
Ground Waters	Solution	Caves Dolines Karst topography	Solution (as in surface running water)	Precipitations due to 1- evaporation 2- loss of acidity 3- chemical reactions Loss of speed	Emergence terraces Stalactites and stalagmites Sediment cement (cavity and vein fills) replacement (petrified trunks)

Table A3. A Table used to determine the geo-morphological processes taking mean temperatures and precipitations into consideration

Climatic Characteristics and the actuating processes in regions established by Peltier (1950)

Morphogenetic Region	Boundaries calculated from annual averages		Morphological characteristics
	Temp (º C)	Prec (in mm)	
Glacial	-18 to 7	0 to 1150	- glacial erosion - snow accumulation - wind action
Periglacial	-15 to - 1	125 to 1400	- accentuated collective movements - moderate to strong wind action - weak effect of running water
Northern	- 9 to 3	250 - 1500	- moderate glacial action - light to moderate wind action
Maritime	2 to 21	1300 to 1900	- moderate effect of running water - accentuated collective movement action - moderate to strong running water action
Jungle	16 to 29	1400 to 2300	- accentuated collective movement action - light effect of slope-wash - no wind action
Moderate	3 to 29	900 to 1500	- maximum effect of collective movements - light glacial action in colder areas - insignificant wind action, except in coastal areas
Savannah	12 - 29	650 to 1300	- light to strong running water action - moderate wind action
Semi-Arid	2 to 29	250 to 650	-- strong wind action - moderate to strong running water action
Arid	13 to 29	0- 400	- strong wind action - light action of running water and collective movements

Excerpt from: Christofoletti, A. (1980). Geomorfologia. 2ª Edición. Blucher. Ltda.
(Christofoletti, A. (1980). Geomorphology. 2nd Edition. Blucher. Ltd.)

Soil Classification

Textural Triangle according to Percentages of Sand, Mud and Clay

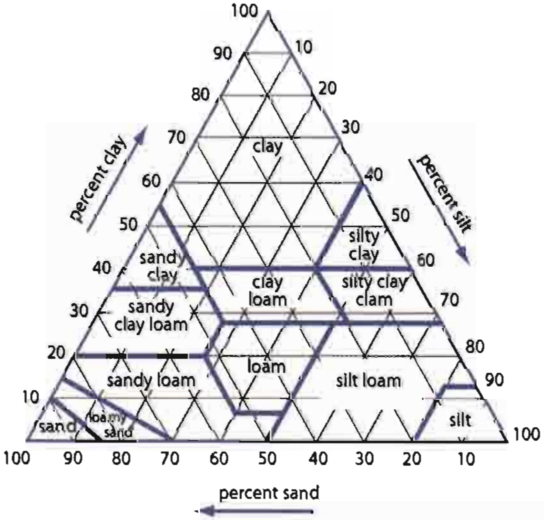


Fig. A4.

Social and Economic Concepts

Economic and Financial Instruments: These are arrangements whereby a relationship is established for the rendering of, and payment for, a service. In normal situations of market transactions, price is the economic instrument par excellence. In the case of loans, the interest rate acts as a financial instrument. However, in many cases, such as in a vulnerability reduction service, it is necessary to make explicit the economic instrument through which beneficiaries are identified, as well as the ways in which a fraction of those benefits may be recovered by means of a payment plan.

Income Distribution: This is a global economic indicator that shows the relationship between the population and national income during a specific period. It shows how national income is distributed among the various components of production (land, labor, capital and organization). In this manner, income corresponds to land; salaries and wages to labor; profits and interest to capital, and benefits to organization. The combination of salaries, wages, profits, interests and income make up the national revenue, which is distributed among all those who have contributed to generating it. [6]

Poverty: Poverty is a complex and multi-dimensional phenomenon, and thus there are many definitions and ways of measuring it. Traditionally, poverty has been defined as a state of material deprivation, measured through the individual's or the family's income or consumption. However, as ECLAC puts it, not only should the lack of basic material needs be taken into account, but also personal self-realization, participation in society, environmental quality, freedom and human rights.

Extreme Poverty: Extreme or absolute poverty is the lack of the necessary income to satisfy basic food needs. These needs are usually expressed in terms of minimum calorie requirements. There is also a definition applied to general or relative poverty, which is the lack of the income necessary to satisfy both basic food needs and other kinds of basic needs, such as clothing, energy and housing. [7]

Assets: An asset is everything of value which a person or a company owns, including accounts receivable, real and tangible assets, such as land, buildings, factories, machinery, furnishings and other goods, and financial assets: money, securities, credit, and intangibles such as copyright, ideas, knowledge, know-how, brands and so on.

Poverty Percentage Index (FGT_0): This indicator, known as the Incidence or Headcount Index, measures the proportion of individuals or families who are below the Poverty Line, and represents the pov-

[6] According to http://www.definicion.org/distribucion-del-ingreso. 10/01/07.

[7] See UNDP Poverty Report 2000, at http://www.undp.org/povertyreport/. 10/01/07.

erty "incidence", "predominance" or "headcount". This index is determined by taking the number of individuals or households with incomes below the Poverty Line, from among the total population. The index shows the proportion of the total population whose income is below the Poverty Line, but does not determine how far or how close the individuals or households are to that line.

Poverty Gap Percentage Index (FGT_1): Measures the "depth" of poverty and indicates the average distance of poor individuals or families from the Poverty Line, weighted by the incidence of poverty. It is obtained by multiplying the poverty percentage index by the income gap coefficient, where the latter is defined by the difference between the poverty gap and the average income of poor people in each locality; all of which is divided by the Poverty Line.

This indicator shows that the closer poor people's income is to the Poverty Line, the closer to zero the indicator will tend to be indicating that poverty is not so severe. On the other hand, if the average income of the poor tends to move away from the Poverty Line, the index approaches one, indicating that poverty is very severe.

Severity of Poverty Index or Median Quadratic Distance (FGT_2): This is a severity of poverty indicator; it overcomes the weak points of the Poverty Gap Index, awarding greater weight to the income of poorer people. For this reason, if the income of individuals or families is very close to the Poverty Line, FGT_2 tends to take value 0 (zero). On the other hand, if the income of the poor is very far from the Poverty Line, FGT_2 tends to show values close to FGT_0. It is calculated by taking the square of the sum of the income gap coefficients for each locality multiplied by the inverse of the total population.

Literacy Rate: Shows the percentage of people who are considered to be literate. It is calculated by taking the number of literate people in each locality, as a percentage of the total population.

Illiteracy Rate: Shows the percentage of people considered to be illiterate (who cannot read or write). It is calculated as a ratio between the illiterate population in each locality and the total population.

Social Security Rate: Shows the percentage of the population covered by the social security system (in the case of Costa Rica). It is calculated by taking the number of people in each locality who have coverage, divided by the total population.

Lack of Social Security Rate: Shows the percentage of the population not covered by the social security system. It is calculated by taking the number of people in each locality who do not have coverage divided by the total population.

Flood Index: This indicator attempts to provide an aggregate measurement of the localities in which various flood events have been reported. Values close to 1 (one) are assigned to localities which report a greater number of floods and 0 (zero) to those which report fewer disasters, within a specific period of time. It is important to note that this type of indicator only reflects the frequency of floods in a specific locality in relation to the total population (municipality or province) for the purpose of comparison. It does not provide a measurement of the intensity of flooding in the different localities.

Lorenz Curve: This is a relative representation of income distribution for households or individuals. It is a graph in which the accumulated percentage of households or individuals is plotted on the horizontal axis, and the percentage of accumulated income on the vertical axis.

Gini Coefficient: The Gini index measures the concentration of wealth and is calculated by means of the Lorenz Curve. It measures the relative inequality of income, showing values between zero and one. The closer the Gini index is to one, the greater the concentration of income in the population. On the other hand, the closer the index is to zero, the more equitable the distribution of income. It is calculated by obtaining the area between the 45º line and the Lorenz Curve, where the 45º curve represents a situation of perfect equity.

Polarization Index: Attempts to measure the disappearance of the middle class and the formation of extreme distribution groups. The index divides income distribution into two groups. It shows a value equal to 0 (zero) if there is no polarization. In this case, there is a perfect distribution of income. It shows a value of 1 (one) if there is complete polarization, in which case there is a perfectly bimodal distribution of income in the group being studied. It is calculated by duplicating the area between the Lorenz Curve and the line tangent to the income median point.

Employment Rate: This is the percentage of the population which is employed. The calculation of this rate depends on the parameters established by the statistics and census bureaus; the population to be measured will vary. In the case of Costa Rica, the population aged 12 and over is measured.

Open Unemployment Rate: This is the percentage of the population which is unemployed, in relation to the workforce. The workforce is defined as both employed and unemployed individuals, in accordance to the criteria used by the statistics and census bureaus of each country.

Economically Inactive Population: These are all of the people of 12 years of age and over who did not work during the reference week, nor looked for work during the previous five weeks. The group includes: pensioners and retired individuals, students, people who work at home, people who are unable to work and other inactive people. That is, all the people who do not belong to the workforce.

Economically Active Population: All the people aged 12 and over who worked during the reference week.

Poverty Line: The limit beyond which quality of life or welfare levels become socially unacceptable. It is the limit beyond which income is insufficient to cover the basic needs of a human being, where food staples play an important role in indicating poverty measurement.

Health Insurance and Lack of Health Insurance: A person, man or woman, is covered by health insurance when he or she has the right to receive, in full or in part, the benefits of Health Insurance. The person must fulfill certain conditions regarding dues, relationship with or economic dependence on the affiliated member, or the family's socio-economic situation. A person is not covered when he or she does not fulfill the required conditions, and therefore does not have the right to receive the partial benefits of Health Insurance.

Good, Medium and Poor Quality Housing: This is the classification established by the National Statistics and Census Institute (INEC in Spanish) of Costa Rica, where the parameters to be considered are the types of material: the state of the walls, roof and floors; the availability of basic utilities such as electricity, water and sanitation.

Average Number of Deaths by Flood: Measures the number of people deceased per year in floods per geographic locality in which the deaths were reported, during the period of time established for the analysis.

Death by Flood Vulnerability Index (IVMI / DFVI): A relative indicator (in this case, within the municipality), which measures the degree of historical vulnerability to death by flood in a specific sub-region within the municipality. It is calculated by measuring the distance between average deaths in the sub-region and the minimum number of deaths in all the sub-regions, divided by the distance between the maximum and minimum number of deaths in the sub-regions:

$$IVMI = \frac{MPI_i - Min\{MPI_i, ..., MPI_n\}}{Max\{MPI_i, ..., MPI_n\} - Min\{MPI_i, ..., MPI_n\}}$$

MPIi:
(DFI_i) Average number of Deaths by Flood in locality i.

$Min\{MPI_i, ..., MPI_n\}$: $(Min\{DFI_i, ..., DPI_n\})$
Minimum number of Deaths by Flood in the total number of observations.

$Max\{MPI_i, ..., MPI_n\}$: $(Max\{DFI_i, ..., DFI_n\})$
Maximum number of Deaths by Flood in the total number of observations.

This index permits comparisons in the interior of sub-regions of the municipality. It will show a value close to 1 (one) for localities which are highly vulnerable, and a value close to 0 (zero) for those which are less vulnerable to deaths by flood.

Average Number of Victims per Flood: Measures the number of people who are injured or wounded in floods per year, per geographic locality where deaths were reported, during the period of time established for the analysis.

Flood Victims Vulnerability Index: This is calculated in the same way as the Death by Flood Index, except that in this case, the parameter employed is the average number of victims per flood. It will show values close to 1 (one) in highly vulnerable localities, and close to 0 (zero) in low vulnerability locations.

Average Number of Dwellings Affected by Floods: Measures the number of dwellings affected by floods per year, area and period of time.

Housing Affected by Floods Vulnerability Index: This is calculated in the same manner as the Death by Flood Vulnerability Index and the Flood Victims Vulnerability Index, except that this index considers the number of houses affected by floods. It produces values close to 1 (one) when vulnerability is high and to 0 (zero) when it is low.

Composite Flood Vulnerability Index (a): (IVCI / CFVI) This indicator can be composed of various indicators. The manual has used, for example, the poverty percentage indices, the Flood Victims Vulnerability Index and the Housing Affected by Floods Vulnerability Index. It seeks to measure vulnerability to floods in a wider spectrum, relating poverty factors, human vulnerability factors and housing vulnerability factors to achieve a basic assets indicator.

This indicator can include other variables considered relevant in the case of floods. In this case, the CFVI includes various social and economic indicators which can be produced. The preparation of indicators simply requires systematization and response to the objectives for which they are needed in the analysis of disasters and population vulnerability (for further information on the preparation of such indicators, see Sudhir Anand and Amartya Sen, "Concepts of Human Development and Poverty. A Multidimensional Perspective" and the Technical Note accompanying the Human Development report, 1997).

The formula employed for its calculation was:

$$IVCI = \left[1/3\,(P_1^{\alpha} + P_2^{\alpha} + P_3^{\alpha})\right]^{1/\alpha}$$

P_1 : Poverty Percentage Index.
P_2 : Flood Victims Vulnerability Index.
P_3: Housing Affected by Floods Vulnerability Index.
$\alpha = 3$

The index uses a value of α equal to 3 (three) in order to assign a greater weight to the component where vulnerability is greater. Consequently, if α increases, the CFVI will tend to take the value of the component in which vulnerability is greater. Values closer to 0 (zero) show that there is no degree of vulnerability to flooding in a specific locality, and values close to 100 (one hundred) show maximum composite vulnerability to floods.

In order to make a comparison between municipalities and determine which the districts with higher vulnerability may be, the maximum and minimum values must be taken for all the municipalities to be compared. For the analysis proposed in this manual, the comparison will be made at the cantonal level; that is, the districts of the municipality of San José will be taken, and these cannot be compared to districts in another municipality, unless data for the latter are included and maximum and minimum values are obtained for the two provinces to be compared. This is due to the specific characteristics of vulnerability measurement and the geographic unit used for quantification.

For the **Composite Flood Vulnerability Index (b)**, the same analysis as in type (a) is indicated, except that here, the Poverty Percentage Index, the Flood Victims Vulnerability Index and the Economic Loss Vulnerability Index are taken into account.

Internal Benefit Rate: This is the inferred rate, in which the difference between the present value of the benefits and the cost of the project, after deducting the initial investment, is equal to zero.

It is calculated as follows:

$$I_0 = \sum_{i=1}^{n} \frac{(B_i - C_i)^n}{(1+Tir)^n}$$

Tir = Ibr : Internal Benefit Rate.
I_0 : Initial Investment.
$(B_i - C_i)$: Net income for period i.

In general, if a time horizon greater than three years is used, complications will tend to arise, and therefore, the result may be found by using interpolation methods or by means of software such as Excel, as shown in the table below:

B8 | fx =TIR(B2:B7)

	A	B	C
1	Year	Data	Description
2	0	-70000	Initial Investment
3	1	12000	Net revenue for the first year
4	2	15000	Net revenue in the second year
5	3	18000	Net revenue for the third year
6	4	21000	Net revenue from the fourth year
7	5	26000	Net income of the fifth year
8	IRR	9%	

Table A4.

Capital Investment: A monetary measurement which shows investment in construction, acquisition of processes, equipment and machinery, and inventory variations.

Investment in Prevention and Mitigation: A monetary measurement which shows investment in the acquisition of processes (increase in knowledge, sound practices, etc.), structures or construction, equipment and machinery and variations in stock, for the purpose of prevention and mitigation of disaster impact. Normally, two large groups are identified: structural and non-structural. In general, a combination of these is found (for example, an Early Warning System supported by equipment, or new legislation to improve building codes, etc.).

Table A5.

First Stage Regressions Results
Beta Parameters of Initial Regressions with EMNV 98[1]

		Independent Variables	Managua	Pacif Urban	Pacif Rural	Central Urban	Central Rural	Atlantic Urban	Atlantic Rural
Household	Materials	BPARED Good Wall	0.1823 (0.0483)	0.0397 (0.0386)	0.2117 (0.0464)	0.0878 (0.0475)	-0.0790 (0.0731)	0.0347 (0.0709)	0.2438 (0.2712)
Household	Materials	MPARED Poor Wall	- -	0.0406 (0.0907)	0.0517 (0.0674)	- -	- -	0.2246 (0.2064)	-0.0730 (0.01164)
Household	Materials	BPISO Good Flooring	0.000 (0.0551)	0.0523 (0.0533)	0.023 (0.0602)	0.056 (0.0613)	0.1146 (0.0736)	0.1476 (0.0968)	0.4002 (0.2971)
Household	Materials	MPISO Poor Flooring	- -	-0.1310 (0.0557)	- -	-0.1160 (0.0578)	0.0000 (0.0000)	-0.2500 (0.822)	-0.0480 (0.0747)
Household	Materials	BTECHO Roof	0.1337 (0.0897)	0.0823 (0.0383)	0.0000 (0.0393)	0.1081 (0.0501)	0.0943 (0.0336)	0.5054 (0.1960)	0.0621 (0.1274)
Household	Materials	MTECHO Poor Roof	- -	0.1672 (0.1295)	-0.1090 (0.0899)	- -	- -	0.2694 (0.3358)	-0.0420 (0.1314)
Household	Type	BVIVIEN Good Household	- 0.7130 (0.5025)	2.683 (0.4476)	0.5074 (0.3138)	- -	0.9178 0.1919	0.6704 (0.4737)	0.1566 (0.5570)
Household	Type	MVIVIEN Poor Household	- -	-0.0520 (0.1215)	-0.0860 (0.0917)	- -	- -	- 0.0830 (0.2865)	- 0.1940 (0.1175)
Household	Type	COCINA Kitchen in Exclusive Room	0.1364 (0.0484)	- -	0.0221 (0.0406)	-0.0040 (0.0515)	0.1870 (0.0400)	-0.0750 (0.0690)	0.1695 (0.0695)
Household	Type	VPROPIA Owned Household	-0.0140 (0.0482)	0.0288 (0.0384)	0.0963 (0.0396)	-0.0410 (0.0499)	0.1157 (0.0327)	0.1814 (0.0618)	0.2607 (0.586)
Household	Type	VALQUIL Household	0.4499 (0.1116)	0.0346 (0.0637)	-0.1520 (0.2613)	0.2293 (0.0896)	0.9311 (0.1410)	0.0687 (0.1191)	-0.3950 (0.3308)

Independent Variables			Significant Regions						
			Managua	Pacif		Central		Atlantic	
				Urban	Rural	Urban	Rural	Urban	Rural
Services	Water	BAGUA Water	0.0563 (0.0526)	0.1374 (0.0411)	0.1219 (0.1064)	0.1374 (0.0532)	0.2324 (0.0876)	0.0354 (0.0854)	0.2200 (0.2254)
		MRAGUA Poor Rural Water	- -	- -	- -	- -	- -	- -	0.0284 (0.0600)
		MUAGUA Poor Urban Water	- -	-0.0850 (0.0647)	- -	- -	- -	-0.0900 (0.0763)	- -
		LETRINA Existence of Latrine	-0.0100 (0.1210)	0.0039 (0.0869)	-0.0200 (0.0465)	0.1092 (0.0863)	0.0080 (0.0363)	0.0205 (0.0909)	0.0828 (0.0651)
		CONAGNE Toilet With Sewage Disposal	-0.0030 (0.1297)	0.1523 (0.0997)	1.5020 (0.4189)	0.2802 (0.1000)	0.4147 (0.4216)	-0.3010 (0.3651)	- -
		SINAGNE Toilet Without Sewage Disposal	-0.1940 (0.1483)	0.0921 (0.1030)	0.4668 (0.1732)	0.2871 (0.1163)	0.4395 (0.2501)	0.4402 (0.1566)	- -
	Light	BLUZ Good Lighting	- 0.0250 (0.1114)	0.1970 (0.0631)	0.1254 (0.0413)	0.2306 (0.0648)	0.1169 (0.0416)	0.2223 (0.0797)	0.0924 (0.1208)
Demography	People	TPERV People in Household	- -	-0.0610 (0.0096)	-0.0460 (0.0104)	-0.0660 (0.0129)	-0.0690 (0.0091)	-0.0550 (0.0120)	-0.0600 (0.0163)
		PME12 People ≤ 12 years old	-0.5520 (0.1340)	-0.4070 (0.1022)	-0.3980 (0.1132)	-0.2400 (0.1271)	-0.4320 (0.0949)	-0.3830 (0.2105)	-0.4100 (0.1661)
		PMA65 eople ≥ 65 years old	-0.0680 (0.1475)	0.0386 (0.1122)	0.0877 (0.1150)	-0.1130 (0.1546)	-0.1920 (0.1204)	0.2805 (0.2574)	-0.7640 (0.2288)
		M1865 Perc. Educated People Between 18-65 years old	- -	- -	0.0174 (0.0175)	- -	- -	0.0403 (0.0215)	- -
	Head of Household	JMUJER Women	0.0252 (0.0712)	-0.0300 (0.0497)	-0.0310 (0.0642)	-0.0720 (0.0698)	-0.0350 (0.0608)	0.1898 (0.0860)	-0.2300 (0.1210)
		JEFUNI Cohabitation	0.0030 (0.0788)	-0.1080 (0.0572)	-0.0030 (0.0657)	-0.0940 (0.0762)	-0.0110 (0.0655)	0.1792 (0.0960)	-0.1900 (0.1179)
		JEFIND Indigenous Speaking	-0.5300 (0.6341)	0.0634 (0.5418)	- -	- -	- -	0.0330 (0.2984)	-6.4500 (1.7740)
		JEFCAS Married	-0.0190 (0.0775)	-0.0230 (0.0569)	-0.0030 (0.0690)	0.0196 (0.0764)	0.0297 (0.0621)	0.1584 (0.0997)	-0.2080 (0.1152)
	Others	PINDIG Perc. People Speak Indigenous Languaje	0.3954 (0.8201)	-1.3800 (2.3470)	0.0000 (0.0000)	0.0000 (0.0000)	-1.3100 (2.3120)	0.1633 (0.3061)	6.3180 (1.7880)
		THIJNVI Total Total of Children Born Alive	-0.0250 (0.0099)	-0.0020 (0.0077)	-0.0230 (0.0063)	-0.0060 (0.0087)	-0.0080 (0.0059)	0.0085 (0.0119)	0.0000 (0.0086)
		HACIN Overcrowding Index	- 0.0820 (0.0119)	- 0.0180 (0.0102)	- 0.0150 (0.0106)	- 0.0610 (0.0143)	- 0.0270 (0.0096)	- 0.0460 (0.0169)	- 0.0240 (0.0163)

[1] Standard errors in parenthesis. The correct calculation of the error is a fundamental part of any Map of Extreme Poverty, since without it it is impossible to determine if the observed differences in the estimate are significant or not. Cells with no information correspond to unused variables for the corresponding significant region.

Source: Translated from the Spanish version (EMNV).

VARIABLES RELATED TO HOUSING, COMMON TO THE 1995 CENSUS AND EMNV 98
(a national survey carried out in Nicaragua on quality of life)

A. Variables related to Dwelling Materials

1. BPARED (Sound walls). The house's walls are built of cement or concrete blocks, quarry stone, and Plycem or Nicalit sheeting.
2. MPARED (Poor walls). The house's walls are built of bamboo, cane or palm; rubble or waste materials.
3. BPISO (Sound flooring). The flooring of the dwelling is built of mud bricks, cement brick, mosaic or terrazzo.
4. MPISO (Poor flooring). The flooring of the residence is earth.
5. BTECHO (Sound roof). The house's roof is zinc, or Plycem or Nicalit sheeting.
6. MTECHO (Poor roof). The house's roof is made of straw or similar material, or rubble or waste materials.

B. Variables related to the Type of Dwelling

7. BVIVIEN (Good dwelling). The dwelling is a detached house with a garden.
8. MVIVIEN (Poor dwelling). The dwelling is improvised, or a shack or a hut.
9. COCINA (Separate kitchen). The dwelling has a room specifically set up as a kitchen.
10. VPROPIA (dwelling is owned). The inhabitant holds the deed to the dwelling.
11. VALQUIL (Rented dwelling). The dwelling is rented by the inhabitants.

C. Variables related to Water Supply.

12. BAGUA (Good quality water). The dwelling obtains water from pipes inside the dwelling, both in urban and in rural areas.
13. MRAGUA (Poor water, rural area). In a rural area, the dwelling obtains water from a river, spring or stream.
14. MUAGUA (Poor water, urban area). In an urban area, the dwelling obtains water from a public supply or from a river, spring or stream.
15. LATRINE (Availability of latrine). The dwelling is provided with a latrine.
16. CONAGNE (Sewage service). The dwelling is connected to sewage disposal services.
17. SINAGNE (No sewage service). The dwelling is not connected to a sewage disposal service.

D. Variables related to Lighting

18. BLUZ (Good lighting). Electric power is available in the dwelling.

E. Demographic Variables.

19. TPERV (Individuals in the dwelling). The total number of persons in the dwelling.
20. PMEI12 (Percentage of persons aged 12 or less). The proportion of persons of 12 years of age or less, with respect to the total number of persons in the residence.
21. PMAI65 (Percentage of persons aged 65 or over). The proportion of people of 65 years of age or over, with respect to the total number of individuals in the dwelling.
22. M1865 (Average education of persons aged between 18 and 65). Average education levels of people aged between 18 and 65 in the dwelling.

F. Variables related to Head of Household

23. JMUJER (Female Head of Household). The head of the household is a woman.
24. JEFUNI (Head in union). The head of the household is in a common-law marriage or cohabitation.
25. JEFIND (Head speaks indigenous language). The head of the household speaks miskito and/or sumo.
26. JEFCAS (Married Head). The head of the household is married.

G. Variables related to other characteristics of the dwelling´s Inhabitants.

27. PINDIG (Percentage of people who speak indigenous language). The proportion of total number of individuals who speak miskito and/or sumo since childhood, with respect to the total number of people in the dwelling.
28. THIJNVI (Total infants born alive). The total number of children born alive in the dwelling.
29. HACIN (Overcrowding index). The total number of persons per room used exclusively for sleeping in the house.

Priorities of the Hyogo Plan of Action for 2005-2015

Increasing resilience of nations and communities in the face of disasters

The following priorities form the basis of the Hyogo Plan of Action for 2005-2015. With the aim of achieving the objectives mentioned above, the following priority actions are listed, among others:

- It is the responsibility of the State to promote sustainable development and the adoption of effective measures for the reduction of disaster risk, in order to protect the population within its territory, the infrastructure and other national assets against the impact of disasters. According to the Kobe Plan of Action, these measures must be taken by putting into practice regulatory, legislative and institutional frameworks for the reduction of disaster risk, as well as by the preparation of specific and measurable indicators to observe and take timely measures in localities which are more susceptible to suffering the effects of disasters, and to inform the population.
- As mentioned in the Plan of Action, the starting point for reducing the risk of disaster and promoting a culture of resilience is to gain knowledge of the threats and the physical, social, economic and environmental vulnerability factors, as well as of the short and long term vulnerability factors. This includes, according to the Plan, measures to complement acquired knowledge by means of the generation and updating of information in order to alert the citizens the generation of disaster risk and vulnerability indicators as part of the EWS. This will permit the timely alerting of those exposed through the creation and improvement of facilities and information systems, among which are included databases, statistics, studies for the analysis of long-term changes and emerging factors which may increase vulnerability and risk.
- The role of education is highlighted as a tool for the reduction of the effects of disasters, since a well-informed population is more capable of acting and of resilience. This leads to gathering, compiling and divulging relevant knowledge and information regarding threats, vulnerability factors and capabilities, which should be clearly communicated and accessible through the strengthening of communication networks with disaster experts. Thus, by using specialized knowledge and the latest information and communications technology, it will be easier for the authorities and for the responsible institutions to provide the general public with information both about risks and about the possible ways of facing disaster and the measures which should be taken.

Emphasis is placed on the fact that disaster risk information must be incorporated into the school syllabus in order to reduce that risk. Priority should be given to implementing both local and national programs to promote community participation in the reduction of disaster risk, by using the mass media, in order to encourage a culture of resilience in the face of disasters. Attempts will be made, with the help of research, to strengthen technical and scientific capabilities to produce and apply methodologies, studies and evaluation models of vulnerability factors and make them public so that the population is aware of them

- Among underlying risk factors, may be found economic, social, environmental and land use factors, as well as those related to geological, meteorological and hydrological phenomena, climate variability and change. The Plan incorporates a series of strategies and programs for sectorial development, which seek to encourage ecosystem management and sustainable use, promoting the reduction of risk associated with current climate variability and changes foreseen in the future. Food safety guidelines should also be included as an important factor ensuring the community's resilience, and there is concern that hospitals should be built to resist disaster impacts and that their capacity in disaster situations be strengthened, also in the case of key public institutions and infrastructures. Recommendations should be provided regarding the implementation of risk reduction mechanisms, such as insurance and reinsurance against disaster, encouraging the private sector to participate in disaster reduction activities and the implementation of planning evaluation programs, both in urban and rural areas.

- To reduce impact and loss in areas exposed to disaster hazards, preparation is important, as is the readiness of both authorities and communities. To this end, strengthening measures and the promotion of communication should be encouraged, as well as the preparation of coordinated approaches in order to improve policies, plans and operational mechanisms, which must be periodically revised and updated. Finally, mention is made of the setting up of emergency funds in support of response measures such as recovery and preparedness in disaster situations.

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Recommended Websites

IDRC Website

http://www.idrc.org/es/ev-1-201-1-DO_TOPIC.html 25/01/07
Official website of the International Development Research Centre. It contains a series of documents aimed at the implementation of practical solutions to social, economic and environmental problems. It also encourages research by implementing and putting into practice a series of human development projects.

http://www.desinventar.org/desinventar.html 21/11/06
"Desinventar" database, produced by the social studies network known as "La Red", for the prevention of disasters in Latin America:

Costa Rica's Statistics and Census Institute:
http://www.inec.go.cr 03/01/07

Bolivia's National Statistics Institute:
http://www.ine.gov.bo 03/01/07

Nicaragua's Statistics and Census Institute:
http://www.inec.gob.ni/ 03/01/07.

Vulnerability Indicator Websites

http://www.undp.org/bcpr/disred/documents/publications/rdr/espanol/at/t3.pdf 24/01/07
This website shows a way to calculate risk, refers to Network websites which contain information about different risk and vulnerability indicators, advantages and disadvantages of using some risk indicators, and some references to sources of data and information on natural threats.

http://www.cruzroja.org/salud/redcamp/docs/agua-san-h/Productos%20P1%20y%20P2.doc 24/01/07
A paper by Isaías Chang Urriola is published here on the production of some vulnerability and disaster indicators in Latin America, using DevInfo 4.0 as an information base.

Natural disasters

http://www.portalplanetasedna.com.ar/desastres_naturales.htm 25/01/2007
This webpage shows the different classifications of disasters according to the factors that originate them, as well as aspects of a culture of prevention. It also highlights new technologies used as instruments of prevention and early warning.

http://www.iadb.org/sds/ENV/site_2493_s.htm 25/01/07
The Inter-American Development Bank website shows a series of prevention policies, strategies, working programmes and publications, among other things.

http://www.ciesacr.com
This site shows various studies on economic losses caused by disasters, training courses in economic assessment of investment in the prevention and mitigation of disasters and economic-environmental loss of natural resources.

Journals on Disaster

http://www2.lib.udel.edu/subj/disasters/ej.htm 25/01/07
This site provides links to various journals dealing with disasters and studies on disasters. Specific journals classified according to disaster type can be found.
For example:

- Bulletin of Volcanology (1997-)
- Disaster Prevention and Management: An International Journal (1994-)
- Emerging Infectious Diseases (1995-)
- Fire Technology (1997-)
- Earthquake Engineering and Structural Dynamics (1997-)
- Weather and Forecasting (1986-), among others.

Books and Articles on Disasters

http://www.desenredando.org/public/libros/1998/mpc/MPLC-MOD4_ene-29-2003.pdf
LA RED ("The Network")'s guide to local risk management.

www.sociedadevaluacion.org/noticias/656%5B1%5D.Pol%EDticas.P%FAblicas.pdf 25/01/07
A book on public policies on vulnerability reduction in the face of natural and socio-natural disasters. Vargas, Jorge Enrique.

www.ssn.unam.mx/Postgrado/gestion_riesgo.pdf 25/01/07
Evaluation of the socio-economic impact of the main natural disasters on industry and commerce.

International Charter Website

http://www.disasterscharter.org/main_e.html 25/01/07
Shows a series of news items and information about disasters in which satellite assistance has been indispensable for disaster management and monitoring, risk determination and damage assessment.

Organization of American States Website

http://www.oas.org/searching/advquery.asp 25/01/07
Shows a series of publications related to mitigation and policies employed by OAS member states.

Association of Caribbean States Website

http://www.acs-aec.org/desastres.htm 25/01/07
Includes documents on training workshops, financial mechanisms and other articles on disaster prevention, in which cooperation among member states when disasters occur is underlined.

CRED Website

http://www.cred.be/ 25/01/07
A series of databases on disasters at the international level may be found on this website, as well as news and projects promoted by the Centre for Research on the Epidemiology of Disasters aimed at improving the quality of the population's response to the effects of disasters.
Among the databases on this website, are:
The International Disaster Database (EM-DAT): Provides methodologically-compiled data on global disaster occurrence and impact of disasters.
EM-SEANET: A project to improve the quality of public health response in disaster and conflict-affected populations in Southeast Asia.
The Complex Emergency Database (CE-DAT): Shows standardized and comprehensive data on the impact of emergencies due to disasters have on humans.
The Bibliography Database (EM-BIB): Shows a collection of publications on disasters, conflicts and their human impacts.

National Commission for Space Activities

http://www.conae.gov.ar 25/01/07
Provides space information regarding emergency management processes, using satellite information as a tool for the early detection and monitoring of the different disaster-prone areas.

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Urban Poverty and Environment (UPE)
International Development Research Centre

PO Box 8500, Ottawa, Ontario
Canada
K1G 3H9
Phone: (+1-613) 236-6163
Fax: (+1-613) 238-7230
Email: upe@idrc.ca
www.idrc.ca/upe